# FIFTEENTH ANNUAL COMPUTATIONAL NEUROSCIENCE MEETING CNS\*2006

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Talk and Poster Abstracts (alphabetical on first author)	



Conference venues	<u>r laces to eat</u>	21. Maxie's Wine Bar
1. Dynamic Earth (dinner)	11. Beluga	22 Monston Mash
2. Forrest Hill (workshops)	12. Bann's Vegetarian Restaurant	22. Monster Mash
3. New College (main meeting)	12. Dann 5 Vegetarian Restaurant	23. M&S for takeaway food
4. William Robertson Bldg	13. Bar Rioja	24. Nile Valley
(workshops)	14. Cafe Delos and Cafe Soupson	24. Mile Valley
	•	25. The Outsider
Accommodation	(The Museum of Scotland)	26. Princes St (main shopping
5. Edinburgh City Centre	15. Creeler's	20. Times St (main shopping
Travel Inn		area)
6. Ibis Hotel	16. The Elephant House	27. Starbucks
7. Jury's Hotel	17. The Gallery Restaurant and Bar	27. Star bucks
8. University Accommodation		28. The Villager

Travel

**9.** Train station and Airlink bus stop 10. Bus Station T. Taxis

(National galleries of Scotland)

18. Grassmarket area for a wide choice of bar food

2

### Local Information

### Welcome to CNS 2006 in Edinburgh!

This section has been designed to give you more information on the conference venue and Edinburgh. Inside your registration pack will also find a copy of the conference proceedings, a name badge, any dinner tickets ordered, and some local information on Edinburgh city centre to help you make the most of your free time in Edinburgh. Please contact the conference desk if any of these items are missing.

We hope you enjoy the conference and your stay in Edinburgh.

# **Local Information**

### *Conference and workshop venues:*

#### Conference Venue

The main conference and poster sessions will be held in New College.

New College (map ref 3) Mound Place Edinburgh EH1 2LX

The Workshops will be held in The William Robertson Building and Forrest Hill.

William Robertson Building (map ref 4) George Square, Edinburgh EH8 9JY

Forrest Hill (map ref 2) 5 Forrest Hill, Edinburgh EH1 2QL

### Conference banquet

The Conference banquet will be held on Monday 17<sup>th</sup> July at Dynamic Earth, 112 Holyrood Road, Edinburgh, EH8 8AS (map ref 1). A ticket should be in your registration pack. Additional tickets can be bought at the registration desk.

To get to Dynamic Earth, you can either take the number 35 bus from Chambers Street, taxi or walk (roughly 20mins). Taxis can be picked up on the street or at ranks (map ref **T**). All fares costs £1 on LRT buses, please have exact money as no change is given. Edinburgh bus timetables can be found at: <u>http://www.lothianbuses.co.uk/</u> To walk to the conference dinner, you can follow a scenic route down the Royal Mile.

### Internet Access

Wireless is available throughout the conference location. To use wireless you will be given an account and password at registration which will allow you to connect via services provided by EUCS (Edinburgh University Computing Services). The account will allow you to connect via either VPN (Virtual Private Network) or by the wireless gateway. VPN requires the installation of specialist software, while the wireless gateway works through a simple web form (activated when you try to access any webpage). For more details see: <a href="http://www.ucs.ed.ac.uk/nsd/access/vpnorbs.html">http://www.ucs.ed.ac.uk/nsd/access/vpnorbs.html</a>

### Local Information

## Medical information

Hospital: For urgent treatment, The Royal Infirmary of Edinburgh, Little France, Old Dalkeith Road (t: 0131-536 1000) has an Accident and Emergency Department. Babies and children up to age 13 can also be taken to The Royal Hospital for Sick Children, 9 Sciennes Road (t: 0131-536 0000).

For minor injuries such as sprains, cuts, bites or minor burns, the Western General Hospital, Crewe Road (t: 0131-537 1330) has a walk-in service available every day of the week, all year round, from 9.00 am - 9.00 pm.

## Getting to Edinburgh

Edinburgh is served primarily by Edinburgh Airport, and Glasgow Airport is also accessible. Travel into Edinburgh by taxi, approx fair  $\pounds$ 18, approx journey time 20mins. Alternatively use the frequent <u>Airlink bus</u>, operated by Lothian Region Transport, £3.30 or £5 open return, journey time 25-30mins.

## Travel within Edinburgh

The conference venue and reserved accommodation are situated in the old town of the city centre. Edinburgh's city centre is compact, so you may find that walking is the best way to get around. Edinburgh has a frequent and comprehensive bus service. Be warned that buses do not give change! Taxis are also easy to find on most major thoroughfares. Although the conference venue is a walkable distance from Pollock Hall, bus numbers 14, 30 and 33 run from Dalkeith Road to the Royal Mile.

For further information: www.lothianbuses.co.uk: +44 (0)131 555 6363

Some numbers for local taxi companies:\* City Cabs (Edinburgh) Ltd: (0131) 228 1211 \* Capital Castle Taxis: (0131) 228 2555 \* Southside Cab Co: (0131) 530 0050 \* Accolade Taxis: (0131) 556 5858

# Museums and Galleries:

### National Museums of Scotland

The Royal Museum is a magnificent Victorian building which houses international collections of Decorative Arts, Science and Industry, Archaeology and the Natural World. Some exhibits are millions of years old, others less than a decade. It is situated minutes away from the conference venue, entrance is free.

National Museums of Scotland, Chambers Street, http://www.nms.ac.uk/nms/home/index.php

### National Galleries of Scotland

These magnificent collections of art encompass the 14th century up to the present day, the galleries have preserved and displayed Scotland's national collection of art since 1859. The National Galleries of Scotland comprise of five Edinburgh-based galleries, The Weston Link and two partner galleries, one in the north and one in the south of Scotland. The Mound, Edinburgh, EH2 2EL, www.nationalgalleries.org

### The Royal Botanic Gardens

The Royal Botanic Garden Edinburgh was founded in the 17th century as a Physics Garden, growing medicinal plants. This first Garden was in St Anne's Yard, part of the Holyrood Palace grounds, and occupied an area the size of a tennis court. It now extends to four sites; Edinburgh, Benmore (near Dunoon in Argyll), Logan (near Stranraer in Galloway), and Dawyck (near Peebles in the Borders), and is the second richest collection of plant species in the world.

### The Royal College of Surgeons

Housed in the upper floor of the William Playfair designed Surgeons' Hall, the Pathology Museum has one of the largest collections of pathological anatomy in the United Kingdom and provides valuable material for the study of human disease.

## Historic buildings, walks and places to visit:

### Holyrood Palace

According to legend, David I founded the Palace as an Augustinian monastery in 1128. It is said that the king had a vision in which a cross, or 'rood', belonging to his mother St Margaret appeared between the antlers of an attacking stag. Hence the Abbey's symbol - a stag's head, with its horns framing a cross. It is most famous as the one-time home of Mary Queen of Scots.

### <u>Calton Hill</u>

The acropolis is in fact an unfinished monument - originally called the "National Monument". Initiated in 1816, a year after Napoleon's

### Local Information

defeat at Waterloo, it was meant to be a replica of the Parthenon in Athens, as a memorial to those who had died in the Napoleonic Wars.

### <u>Arthur's Seat</u> Good place for walks and picnics.

### **Cinemas and Theatres**

The Cameo, 38 Home St, Edinburgh, EH3 9LZ ,Tel: 0131 228 2800 The Filmhouse, 88 Lothian Road, Edinburgh, Tel: 0131 228 2688 Omni Centre (multiplex), Greenside Place, Edinburgh,Tel: 0870 240 6020 The Kings Theatre,2 Leven Street, Edinburgh, EH3 9QL, Tel: 0131 529 6000 The Lyceum Theatre, Grindlay Street, Edinburgh, Tel: 0131 248 4848, <u>www.lyceum.org.uk</u> The Traverse Theatre, Cambridge Street, Edinburgh, City of Edinburgh, EH1 2ED, Tel: 0131 228 3223 The Festival Theatre, 13-29 Nicholson Street, Edinburgh, Tel: 0131 529 6000, <u>www.eft.co.uk</u> Music: The Jamhouse, 5 Queen Street, Edinburgh, EH12 1JE, Tel:0131-226- 4380, <u>www.thejamhouse.com</u>

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# **15 July Saturday**

16.00-18.00 Early registration (Main venue, Map reference 3)

# 16 July Sunday

8.00-9.00 Registration

Coding and decoding

- 9:00 Welcome
  9.10 Invited talk: Sophie Deneve
  Bayesian inference and learning with spikes
- 10.10 Rama Natarajan, Quentin Huys, Peter Dayan, Richard Zemel Population Codes for Natural Dynamic Stimuli

10.30 Coffee Break

11.00 Featured talk: Felix Creutzig, Sandra Wohlgemuth, Jan Benda, Andreas Stumpner, Bernhard Ronacher, Andreas V.M. Herz *Time-warp invariant stimulus decoding in an insect auditory system?*11.40 Jan Benda, Andre Longtin, Len Maler

Coding Communication Signals with Synchrony and Asynchrony 12.00 Stefano Panzeri, Ehsan Arabzadeh, Mathew Diamond On the timing precision needed to decode spike times

12.20 Lunch Break

Attention and Memory

14.00 Featured talk: Salva Ardid, Wang Xiao-Jing, Albert Compte Neural mechanisms of the feature-similarity gain principle for attentional processing
14.40 Yasser Roudi, Peter Latham Balanced input to the memory and background neurons during memory retrieval in an associative network
15.00 David Sterratt, David Willshaw Robust performance of inhomogeneous forgetful associative memory networks

15.20-19.00 Poster Session (Posters are listed at the end of the program)

Attention Information coding I Morphology, Anatomy and Development Databases, Software and Neuroinformatics Robots and Silicon Neurons System dynamics I Learning Memory

# **17 July Monday**

Mechanisms at the cellular and synaptic levels

9.00 Invited talk: Fred Wolf

Long-range interactions and multistable pattern formation in visual cortical development 10.00 Alexey Kuznetsov, Nancy Kopell, Charles Wilson

A mechanism for NMDA-activated high-frequency firing in midbrain dopaminergic neurons. 10.20 Panchev Christo

Computing with Active Dendrites

10.40 Coffee Break

## Meeting program 18<sup>th</sup> July

- 11.10 Kyriaki Sidiropoulou, Marian Joels, Panayiota Poirazi Modeling stress-induced adaptations in Ca++ dynamics
- 11.30 Martin Ayling, Stefano Panzeri, Bracci Enrico GABAergic excitation in striatal projection neurons: simulations and experiments
- 11.50 Matthias Hennig, Michael Postlethwaite, Ian Forsythe, Bruce Graham A biophysical model of short-term plasticity at the calyx of Held
- 12.10 Volker Steuber, Jason Rothman, Laurence Cathala, R. Angus Silver
   Short-term depression amplifies gain modulation by tonic inhibition in cerebellar granule cells

12.30 Lunch break

### Sensory and motor systems

14.00 Haruka Nishimura, Ko Sakai *The Direction of Figure is Determined by Asymmetric Surrounding Suppression/Facilitation*14.20 Athena Akrami, Yan Liu, Alessandro Treves, Bharathi Jagadeesh *Categorical processing of continuously morphed natural images in inferotemporal cortex*14.40 Michael Denker, Sébastien Roux, Marc Timme, Alexa Riehle, Sonja Gruen *Phase Synchronization between LFP and Spiking Activity in Motor Cortex During Movement Preparation*

### 15.00 CNS Business Meeting

15.20-18.45 Poster Session (Posters are listed at the end of the program) Cellular mechanisms Synaptic mechanisms Visual system Motor systems Sensory systems Information coding II Functional imaging and EEG

### BANQUET

19.00 Dynamic Earth

# **18 July Tuesday**

Plasticity and learning, from synapse to systems:

9.00 Invited talk: Michael Hausser A dendritic switch for synaptic plasticity in neocortical pyramidal cells
10.00 Kazuhisa Ichikawa, Hoshino Akemi, Kunio Kato Induction of Synaptic Depression by High Frequency Stimulation in Area CA1 of the Rat Hippocampus
10.20 Guy Billings, Mark van Rossum Stability of Spike Timing Dependent Plasticity

### 10.40 Coffee break

- 11.10 Featured talk: Christian Hauptmann, Erwin-Josef Speckmann, Peter Tass Therapeutic rewiring by means of desynchronizing brain stimulation: theoretical and experimental app
- 11.50 Jeffrey McKinstry, Gerald Edelman, Jeffrey Krichmar An Embodied Cerebellar Model for Predictive Motor Control Using Delayed Eligibility Traces
- 12.10 P Bernd Porr, Tomas Kulvicius, Florentin Woergoetter Improved stability and convergence with three factor learning

12.30 Lunch break

Mechanisms of oscillations and synchrony

14.00 Featured talk: Julia Berzhanskaya, Anatoli Gorchetchnikov, Steven Schiff
Switching between gamma and theta: dynamic network control using subthreshold electric fields.
14.40 Maxim Bazhenov, Nikolai Rulkov
Genesis and synchronization properties of fast (beta-gamma range) network oscillations
15.00 Szabolcs Kali, Tamas F. Freund
Interneurons control hippocampal network dynamics in a subtype-specific manner
15.20 Ingo Bojak, David Liley
Self-organized 40 Hz synchronization in a physiological theory of EEG
15.40 Jaime de la Rocha, Brent Doiron, Eric Shea-Brown, Kresimir Josic, Alex Reyes
Mechanisms underlying the development of synchrony: a comprehensive approach
16.00–19.00 Poster Session (Posters are listed at the end of the program)
Hippocampus
Synchronization and Oscillation
System dynamics II
Network properties
Cerebellum
Cortex

Plasticity

# Workshop Schedule

The workshops will be held at the William Robertson Building and Forrest Hill. Please sign up for these during the conference. The exact room allocation will be published during the conference

There is the possibility to spontaneously organize workshops; room size will be limited.

Preliminary workshop abstracts are found on page 21.

	Morning 9.00-12.00	Afternoon 14.00-17.00
	Terminology and Metadata for Modeling and Computational Neuroscience I (Daniel Gardner)	Terminology and Metadata for Modeling and Computational Neuroscience II
	Interoperability of neural simulators (Erik de Schutter)	Cortical microcircuitry (Thomas Wennekers)
	Stochastic dynamics of neurons and networks (Paulo del Guidice & Nicolas Brunel)	Stochastic dynamics of neurons and networks, II
Wednesday	Cortical map development (Jim Bednar)	Extracellular Recordings to Tune Compartmental Models- Tutorial (Carl Gold)
	Functional models of the hippocampal formation (Laurenz Wiskott)	Functional models of the hippocampal formation, II
	Modelling structural plasticity and development (Markus Butz & Arjen van Ooyen).	Modelling structural plasticity and development, II
	Terminology and Metadata for Modeling and Computational Neuroscience, III	Terminology and Metadata for Modeling and Computational Neuroscience, IV
	Interoperability of neural simulators, II	Interoperability of neural simulators, III
	Continuous Attractor Neural Networks - CANNs (Si Wu & Thomas Trappenberg)	Continuous Attractor Neural Networks – CANNs. II
Thursday	Phase response curves: where theory and experiments intersect (Tay Nettof & Horacio Rotstein)	Cortical microcircuitry, II
	Methods of Information Theory in Computational Neuroscience (Alexander Dimitrov & Aurel Lazar)	Methods of Information Theory in Computational Neuroscience, II
	Plasticity and stability (Mark van Rossum)	Exploring large spiking networks using NEST (Marc- Oliver Gewaltig & Hans Ekkehard Plesser)

# **Sunday Poster Session**

Jun	
Attentio	n
S1	Hecke Schrobsdorff, Matthias Ihrke, Bjoern Kabisch, Joerg Behrendt, Marcus Hasselhorn, Michael Herrmann
	A Computational Account of the Negative Priming Effect
S2	David Rotermund, Taylor Katja, Udo Ernst, Pawelzik Klaus, Kreiter Andreas
	Attention improves object discriminability in monkey area V4
S3	Roland Schäfer, Eleni Vasilaki, Walter Senn
	Perceptual learning by modifying top-down connections to V1
S4	Jaeseung Jeong, Dongil Chung, Jaewon Lee, Amir Raz,
	An integrative neural network model for the negative priming effect of Stroop task performance
S5	Anna Kuznetsova, Richard Deth
	Modeling of dopamine D4 receptor-induced regulation of cortical activity
S6	Neill Taylor, Matthew Hartley, John Taylor
50	The Micro-Structure of Attention
<b>S</b> 7	Eirini Mavritsaki, Dietmar Heinke, Glyn Humphreys, Gustavo Deco
57	Suppressive effects in visual search: A neurocomputational analysis of preview search.
<b>S</b> 8	Frank van der Velde, Gwendid van der Voort van der Kleij, Pascal Haazebroek, Marc de Kamps
50	A model of global saliency: Selecting a target object among distractors
S9	A model of global sallency. Selecting a larger object among distractors Axel Hutt, Michael Schrauff
39	
S10	Detection of synchronization in event-related potentials by clustering
S10	Andres Buehlmann, Rita Almeida, Gustavo Deco
	A Model for Modulation of Synchronisation by Attention
	tion Coding I
S11	Don Johnson, Jyotirmai Uppuluri,
~	Detecting Correlated Population Responses
S12	Gaby Schneider
	Which spike train properties shape cross correlograms?
S13	Peter Latham, Arnd Roth, Michael Hausser, Mickey London
	Requiem for the spike?
S14	Mona Sheikh, Don Johnson
	Favorable Recording Criteria for Spike Sorting
S15	Estee Stern, Timothy Fort, Mark Miller, Charles Peskin, Vladimir Brezina
	Decoding modulation of the neuromuscular transform
S16	Marcelo Montemurro, Riccardo Senatore, Stefano Panzeri
	Downward biased estimator of spike timing information
S17	Enrico Rossoni, Jianfeng Feng, Yingchun Deng
~ - /	Dynamics of Moment Neuronal Networks
S18	Alexander Dimitrov, Rony Azouz, Tomas Gedeon
510	Effects of stimulus transformations on estimated functional properties of mechanosensory neurons
S19	Daniel Butts, Liam Paninski
517	Contrast adaptation in descriptions of visual neurons that incorporate spike-history dependence
S20	Fernando Montani, Adam Kohn, Simon Schultz
320	How do stimulus-dependent correlations between VI neurons affect neural coding?
621	
S21	Jonathan Pillow, Liam Paninski
G <b>2 2</b>	Model-based optimal decoding of neural spike trains
S22	Maria V. Sanchez-Vives, Janusz Szczepanski, M. Marta Arnold, Elek Wajnryb
~	Mutual information and redundancy in cortical spike trains during the awake state
S23	Li Zhaoping, Mark Hubener, Akiyuki Anzai
	Efficient stereo coding in the primary visual cortex and its experimental tests by optical imaging and single cell data
S24	Kukjin Kang, Haim Sompolinsky
	Temporal Code and Inter-spike Interval distribution
S25	Rüdiger Kupper, Andreas Knoblauch, Marc-Oliver Gewaltig, Ursula Koerner, Edgar Koerner
	Simulations of signal flow in a functional model of the cortical column
S26	Eilif Muller, Johannes Schemmel, Karlheinz Meier
	Modeling Spike-Frequency Adaptation in an Awake Cortical Network
S27	Martin Nawrot, Clemens Boucsein, Victor Rodriguez-Molina, Sonja Gruen, Stefan Rotter
~_,	Serial correlation of inter-spike intervals in cortical neurons
S28	Hecke Schrobsdorff, Michael Herrmann, Theo Geisel
520	A Feature-Binding Model with Localized Excitations
	III canno Duanty mouch mui Locança Lacianono

Anatomy, Morphology and DevelopmentS29Huo Lu, Hugo Cornelis, Buky Aworinde, David Senseman, James Bower Model-based Comparison of the Passive Electrical Properties of Three Species of Purkinje Cells

S30	Claus Hilgetag, Matthias Goerner, Marcus Kaiser
	Criticality in Clustered Cortical Connectivity
S31	Marcus Kaiser, Claus Hilgetag
~ • •	Multi-clustered cortical networks arise from developmental time windows for spatial growth
S32	Andreas Schierwagen, Alán Alpár, Ulrich Gärtner
<b>GQQ</b>	Scaling properties of pyramidal neurons in mouse somatosensory cortex
S33	Ronald Elburg, Arjen vanOoyen
~ ~ ~	Dendritic Morphology Influences Burst Firing
S34	Carl-Magnus Svensson, Yulia Timofeeva, Stephen Coombes
<b>695</b>	Branching Dendrites with Resonant Membrane
S35	Shyam Srinivasan, Edwin Monuki, Wayne Hayes
<b>G2</b> (	Analysis of morphogen gradient interpretation mechanisms in the developing brain
S36	Tom Stafford, Stuart Wilson
027	Self-organisation explains discontinuities in the somatosensory map
S37	Jianhua Wu, Jianfeng Feng Uinnen hind Multimering Anglasia of Variance for all dataselesis datase
	Hierarchical Multivariate Analysis of Variance for electrophysiological data
Databas	ses, Software, Neuroinformatics
S38	Padraig Gleeson, Volker Steuber, R. Angus Silver
330	NeuroConstruct: a software tool for constructing biologically realistic neural network models in 3D
S39	David Cofer, James Reid, Oleksiy Pochapinskyy, Ying Zhu, Gennady Cymbalyuk, William Heitler, Donald
339	Edwards
	ANIMATLAB: A Physically Accurate 3-D Environment For Behavioral Neurobiology Research
S40	Robert Cannon, Randal Koene, Michael Hasselmo
540	Modelling Neural Systems with Catacomb 3
S41	Ben Torben-Nielsen, Karl Tuyls, Eric Postma
541	EvOL-Neuron: method and prospects
S42	Hugo Cornelis, Erik De Schutter
512	Neurospaces : towards automated model partitioning for parallel computers
S43	Raphael Ritz, Andreas Herz
515	Preparing for the German neuroinformatics node
S44	David Goldberg, Jonathan Victor, Esther Gardner, Daniel Gardner
5	Computational Neuroinformatics: Toward Distributed Neuroscience Data Discovery
S45	Hidetoshi Ikeno, Takuto Nishioka, Takuya Hachida, Ryohei Kanzaki, Yoichi Seki, Izumi Ohzawa, Shiro
~	Usui
	Development and application of CMS based database modules for neuroinformatics
S46	Peter Andras, Hai Nam Ha
	A Scientific Document Management System for Neuroscience
S47	Hiroshi Okamoto, Yukihiro Tsuboshita
	Document retrieval from a citation network of neuroscience articles by continuous-attractor dynamics
S48	Jochen Eppler, Abigail Morrison, Markus Diesmann, Hans Plesser, Marc-Oliver Gewaltig
	Parallel and Distributed Simulation of Large Biological Neural Networks with NEST
S49	Marc-Oliver Gewaltig, Markus Diesmann
	Exploring large-scale models of neural systems with the Neural Simulation Tool NEST
S50	Michael Hines
	Parallel Simulation with NEURON
S51	Hans Plesser, Abigail Morrison, Sirko Straube, Markus Diesmann
	Precise and efficient discrete time neural network simulation
S52	Leslie Smith
	Testing spike detection and sorting algorithms using synthesized noisy spike trains
S53	Stefan Wils, Erik De Schutter
	STEPS: Stochastic Simulation of Reaction-Diffusion in Complex 3-D Environments
S54	Sharon Crook, Padraig Gleeson
	Facilitating Software Interoperability and Model Exchange: XML Standards for Model Specification
	and Silicon Neurons
S55	Martin Pearson, Chris Melhuish, Ben Mitchinson, Tony Prescott
	A Hardware based Brain Stem Sub-Nucleus Model for Brain-Based Robotic Experimentation
S56	Michael Sfakiotakis, Dimitris Tsakiris
	Neural Control of Reactive Behaviors for Undulatory Robots
S57	Tao Geng, Tomas Kulvicius, Bernd Porr, Florentin Woergoetter
	Neural Control and Synaptic Plasticity in a Planar Biped Walking Robot
S58	John Porrill, Paul Dean, Sean Anderson, Mayank Dutia, John Menzies, Chris Melhuish, Tony Pipe, Alexander Lenz,

Thanushan Balakrishnan, Functions of Distributed Plasticity in a Biologically-Inspired Control System

S59	Dynamics I Antti Saarinen, Marja-Leena Linne, Olli Yli-Harja
557	Statistical similarity measures for stochastic firing data
S60	Jiaxiang Zhang, Rafal Bogacz
~ ~ ~	Optimal decision making with realistic bounds on neuronal activity
S61	Marc de Kamps, Frank van der Velde
	An efficient solution for the population density equation
S62	Vasily Vakorin, Gordon Sarty
	Inferring neural activity from BOLD via nonlinear optimization
S63	John Cressman, Jokubas Ziburkus, Ernest Barreto, Steven Schiff
	Investigating seizures with reduced models of potassium dynamics
S64	Benjamin Lindner
	Is the superposition of many independent spike trains a Poisson process?
S65	Gonzalo G. de Polavieja,, Srikanth Ramaswamy, Fabiano Baroni, Pablo Varona,
	Time-scales in the interplay between calcium and voltage dynamics
S66	Uwe Roehner, Jan Benda
~	Switching from integrators to resonators
S67	Alessandro Torcini, Stefano Luccioli, Thomas Kreuz
0.00	Coherent response of the Hodgkin-Huxley neuron in the high-input regime
S68	Petr Marsalek, Martin Zapotocky
560	A model of a mechanoreceptor and sensory circuit in the fruit fly Wolfram Erlhagen, Fabian Chersi, Albert Mukovskiy, Leonardo Fogassi, Pier Francesco Ferrari
S69	
S70	A model of intention understanding based on learned chains of motor acts in the parietal lobe Carrie Williams, Stephen DeWeerth
370	Resonance tuning of a neuromechanical system with two negative sensory feedback configurations
S71	Ernest Barreto, Clayton Fan, Paul So, Steven Schiff
5/1	A model for electric field modulation of propagating neuronal activity
S72	Michelle Rudolph, Alain Destexhe
0/2	How Much Can We Trust Neural Simulation Strategies?
S73	Matthijs van der Meer, Mark van Rossum
	A model of anticipation in the rodent head-direction system
S74	Tim Vogels, Larry Abbott
	Signal Propagation and Switching in Networks
S75	Ruediger Zillmer, Roberto Livi, Antonio Politi, Alessandro Torcini
	Desynchronization in diluted neural networks
S76	Lewi Jeremy, Robert Butera, Liam Paninski
	Efficient model-based information-theoretic design of experiments
S77	Thomas Kreuz, Stefano Luccioli, Alessandro Torcini
	Coherence resonance due to correlated noise in neuronal models
S78	Wojcik Grzegorz, Wieslaw Kaminski
	Grid-based Parallel Simulations of Mammalian Cortical Hypercolumn
Learnir	α
S79	André Grüning
0.17	Towards increased biological plausibility: A reinforcement version of Elman back-propagation
S80	Gediminas Luksys, Carmen Sandi, Wulfram Gerstner
	Effects of Stress & Genotype on Meta-parameter Dynamics in a Simple Reinforcement Learning Mod
S81	Peter Redgrave, Kevin Gurney
	Timing is everything: Dopamine signals in temporal difference learning
S82	Christiane Linster, Daniel Rubin, Nathalie Mandairon, Casara Ferretti, Conor Stack, Thomas Cleland
	Activation of cholinergic receptors in the olfactory bulb modulates odor discrimination
S83	Boris Vladimirski, Eleni Vasilaki, Stefano Fusi, Walter Senn
	Hebbian reinforcement learning with stochastic binary synapses follows the reward gradient
S84	Christoph Kolodziejski, Bernd Porr, Florentin Woergoetter
	Fast, flexible and adaptive motor control achieved by pairing neuronal learning with recruitment
S85	Krishna Miyapuram, Raju Bapi, Kenji Doya
	Visuomotor Mappings and Sequence Learning
S86	Jeffrey McKinstry, Justin Kerk
	Learning to perform cognitive tasks by associating sequences with expected future reward
S87	Federica Menghini, Nicola van Rijsbergen, Alessandro Treves
	Modelling adaptation aftereffects in associative memory
	Quentin Huys, Peter Dayan
S88	Optimal helplessness: a normative framework for depression
S88 S89	

S90	Frédéric Henry, Emmanuel Daucé, Hédi Soula
	Temporal Pattern identification using Spike-Timing Dependent Plasticity
S91	Stefano Fusi, Curti Emanuele, Wang Xiao-Jing

- SystemSubscriptionSubscriptionMechanisms for the formation of neural representations of abstract rulesS92Daniel Ben Dayan-Rubin, Stefano Fusi
- Storing sparse random patterns with cascade synapses
   Max Garagnani, Thomas Wennekers, Friedemann Pulvermüller
   A neuronal model of the language cortex

### Memory

S94	Anthony Burkitt, Hamish Meffin, David Grayden
	Scheme for Temporal Pattern Recognition
S95	Andrew Lulham, Simon Vogt, Rafal Bogacz, Malcolm W. Brown
	Anti-Hebbian learning may underlie both familiarity discrimination and feature extraction
S96	James Stone, Peter Jupp
	Modelling Spontaneous Recovery of Memory
S97	Patrick Coskren, Patrick Hof, Susan Wearne
	Stability and robustness in an attractor network are influenced by degree of morphology reduction
S98	Raoul-Martin Memmesheimer, Marc Timme
	Spike Patterns in Heterogeneous Neural Networks
S99	Andrea Greve, Mark van Rossum, David I. Donaldson
	single neuronal network model of familiarity and recollection based recognition memory.
S100	Alan Bond
	A system-level brain model of spatial working memory and its impairment
S101	Andreea Lazar, Raul Muresan, Ellen Stadtler, Matthias Munk, Gordon Pipa
	Importance of electrophysiological signal features assessed by classification trees
S102	Dorothea Haemmerer, Shu-Chen Li, Timo von Oertzen, Ulman Lindenberger
	Aging and Reward Modulation of the Episodic Memory Circuitry: A Neurocomputational Inquiry
S103	Wei Wu, Diek W. Wheeler, Ellen Stadtler, Matthias Munk, Gordon Pipa
	Performance-dependent changes of spike and LFP in monkey prefrontal cortex during short-term memory
S104	Joaquin Torres, Jesus M. Cortes, J. Marro, Hilbert J. Kappen

Attractor Neural Networks with Activity-Dependent Synapses: The Role of Synaptic Facilitation

## Monday Poster Session

### Cellular Mechanisms

M1 Terrence Wright, Robert Butera Effects of Electrical Coupling on Excitatory Coupled Pacemaker Neurons in the pre-Bötzinger Complex M2 Asli Ayaz, Frances Chance What Defines Balanced Synaptic Input? Laurent Badel, Sandrine Lefort, Carl Petersen, Wulfram Gerstner, Magnus Richardson M3 Measuring the instantaneous I-V curve for subthreshold and spike initiation voltages M4 Romain Brette, Zuzanna Piwkowska, Michelle Rudolph, Thierry Bal, Alain Destexhe A non-parametric electrode model for intracellular recording M5 Quentin Huys, Liam Paninski Model-based optimal interpolation and filtering for noisy, intermittent biophysical recordings M6 Astrid Prinz, En Hong, Adam L. Taylor, Comparison of spiking neurons based on conductance space exploration of model neurons from two phyla M7 Darrell Haufler, France Morin, Jean-Claude Lacaille, Frances Skinner Parameter Estimation in Single Compartment Neuron Models using a Synchronization Based Method M8 Carl Gold, Christof Koch Using Extracellular Action Potential Recordings To Constrain Compartmental Models M9 Fabiano Baroni, Pablo Varona Subthreshold oscillations and neuronal input-output relationship M10 Martin Pospischil, Zuzanna Piwkowska, Michelle Rudolph, Thierry Bal, Alain Destexhe Inhibitory Conductance Dynamics In Cortical Neurons During Activated States M11 Ebba Samuelsson, Jeanette Hellgren Kotaleski Exploring GABAergic and Dopaminergic effects in a minimal model of a medium spiny projection neuron M12 William Mehaffey, Fernando Fernandez, Leonard Maler, Raymond Turner Dendritic GABAb currents can induce a shift to a burst firing mode in ELL M13 Richard Robertson, Kerstin Menne Depolarizing, GABA-Mediated Synaptic Responses and Their Possible Role in Epileptiform Events M14 Raju Bapi, Shesharao Wanjerkhede Investigation of Glutamate and Dopamine Signaling Pathways involved in Reinforcement Learning

# Poster Sessions

M15	Raul Muresan, Cristina Savin, Iosif Ignat
M16	Resonance as an effective mechanism of dynamical stability in large microcircuits of spiking neurons
M16	Gennady Cymbalyuk, Ronald Calabrese, Andrey Olypher, Andrey Shilnikov Regulation of bursting activity of simple units of CPGs
M17	Erik Fransén
1111/	Neural response profile design
M18	Patrick Meuth, Sven Meuth, Hans-Christian Pape, Thomas Budde
IVIIO	A leak potassium current and its functional impact on thalamic relay cell function
M19	Danielle Morel, William Levy
10117	Persistent Sodium is a Better Linearizing Mechanism than the Hyperpolarization-activated Current
M20	Patrick Crotty, William Levy
	Effects of Na+ channel inactivation kinetics on metabolic energy costs of action potentials
M21	Renaud Jolivet, Claudia Clopath, Alexander Rauch, Hans-Rudolf Lüscher, Wulfram Gerstner
	Predicting Neuronal Activity with Simple Models of the Threshold Type
M22	Renaud Jolivet, Pierre Magistretti
	Na,K-ATPase-Specific Spike-Frequency Adaptation
M23	Jutta Kretzberg, Friedrich Kretschmer, Antonia Marin-Burgin
	Effects of multiple spike-initiation zones on signal integration properties of leech touch cells
	ic mechanisms
M24	Katri Hituri, Pablo Achard, Stefan Wils, Marja-Leena Linne, Erik De Schutter
	Stochastic modeling of inositol-1,4,5-trisphosphate receptors in Purkinje cell spine
M25	Antti Pettinen, Tiina Manninen, Olli Yli-Harja, Keijo Ruohonen, Marja-Leena Linne
1426	Parameter estimation for neuronal signaling models: Deterministic and stochastic in silico data
M26	William Gibson, Les Farnell, Bennett Max
M27	A computational model relating changes in cerebral blood volume to synaptic activity in neurons
M27	Gideon Gradwohl, Yoram Grossman
	Excitatory And Inhibitory Synaptic Inputs Are Modulated Through The Spatial Distribution Of Dendritic Voltage- Dependent Channels
M28	David Tam
11/120	Computational Mechanisms for Physiological Adaptation and Reflex Conditioning
M29	Ovidiu Iancu, Patrick Roberts, Jianmei Zhang, Curtis Bell
1412)	Postsynaptic modulation of electrical EPSP size investigated using a compartmental model
M30	Maria Bykhovskaia
11100	Recruitment Of Presynaptic Vesicles And Facilitation Of Transmitter ReleasE
M31	Aviv Mezer, Uri Ashery, Esther Nachliel, Menachem Gutman
-	A comprehensive kinetic model of the exocytotic process
M32	Gabriela Antunes, Antônio Roque
	Activation of CaMKII under different Ca2+ oscillations mediated by PP2B, AC and PDE
M33	Michael Graupner, Nicolas Brunel
	Transitions in a bistable model of the Ca(2+)/calmodulin-dependent protein kinase-phosphatase system
M34	Bill Holmes, Lawrence Grover
	The mechanism of LTP affects dendritic computation
M35	Matthew Kaufman, Sridharan Devarajan, Justin Litchfield
	Action potential backpropagation failure: All-or-none rescue by synaptic input in CA1 obliques
M36	Janette Clark, Bruce Graham
	Spatial and temporal control mechanisms influencing signal integration in a CA1 pyramidal cell model
M37	Yulia Timofeeva, Stephen Coombes, Gabriel Lord
	Branched dendritic tree with active spines
M38	Francisco Veredas, Héctor Mesa
	Synaptic conductance modulation for correlated activity analysis in networks of spiking neurons
M39	Tiina Manninen, Marja-Leena Linne, Keijo Ruohonen
11139	Modeling signal transduction using Itô stochastic differential equations and the Gillespie algorithm
M40	Jose Manuel Benita, Antoni Guillamon, Gustavo Deco, Maria V. Sanchez-Vives
111 TU	A biophysical model to explore the effects of network activity on short-term synaptic depression
	resonation in the contract of the contract of the start of short-term synaptic depression
Visual	system
M41	Drazen Domijan, Mia Setic, Domagoj Svegar
	A model of illusory contour formation based on dedritic computation
M42	Udo Ernst, Nadja Schinkel, Pawelzik Klaus, Sunita Mandon, Simon Neitzel, Kreiter Andreas

- on, Simon Neitzel, K Contour detection from quasi-ideal contour integration Brett Graham, David Northmore
- M43 Spiking Neuron Models based on Midbrain Mechanisms that Guide Visual Behavior

# Poster Sessions

M44	Ketan Bajaj, Basabi Bhaumik
	Adaptation induced suppression & facilitation: Effect of intra & extra cellular ionic disturbances
M45	Salva Ardid, Wang Xiao-Jing, Albert Compte
144	Mechanisms of visual motion processing normalization in areas V1 and MT
M46	Drazen Domijan, Mia Setic, Domagoj Svegar,
M47	Modeling statistical processing of visual information
M47	Marcus Frean
N/40	A model for adjustment of the retinotectal mapping, using Eph-dependent ephrin regulation
M48	N. Michael Mayer, Minoru Asada Man modela of the viewal exertise of the atimulus angles affects the man formation
M40	Map models of the visual cortex: The metric of the stimulus space affects the map formation
M49	Yoshiki Kashimori, Yu Ichinose, Kazuhisa Fujita A functional role of interaction between IT cortex and PF cortex in visual categorization task
M50	Ko Sakai, Mitsuharu Ogiya, Shiori Katsumata
NI30	Simultaneous Determination of Depth and Motion in Early Vision
M51	Henning Sprekeler, Laurenz Wiskott
10101	Analytical Derivation of Complex Cell Properties from the Slowness Principle
M52	Floortje Klijn, Mike Denham
	Development of a mechanistic model for explaining the variation in responses of X-cells in the LGN
M53	Andrew Symes, Thomas Wennekers
	Spread of activation along specific lateral pathways in microcircuits of the primary visual cortex
M54	Aman Saleem, Simon Schultz
	Subspace STC analysis using bias correction
M55	Alessio Plebe
	A Model of Angle Selectivity Development in Visual Area V2
M56	Denise Berger, David Warren, Richard Normann, Sonja Gruen
	Spatially organized spike correlation in cat visual cortex
M57	Asya Shpiro, Ruben Moreno-Bote, Nava Rubin, John Rinzel
	Spike frequency adaptation vs. synaptic depression slow processes in neural competition models
Madage	
Motor sy	
M58	Pablo Achard, Erik De Schutter Different models, same outputs
M59	Doris Campos, Carlos Aguirre, Eduardo Serrano, Francisco de Borja Rodríguez, Gonzalo G. de Polavieja, Pablo Varona
11157	Temporal structure in the bursting activity of the leech heartbeat CPG neurons
M60	Roberto Latorre, Francisco de Borja Rodríguez, Pablo Varona
	Reaction to neural signatures through excitatory synapses in Central Pattern Generators models
M61	Osamu Shouno, Johane Takeuchi, Hiroshi Tsujino
	A self-organizing motor-control neural network model inspired by the basal ganglia
M62	Vladimir Brezina
	Functional penetration of variability of motor neuron spike timing through a neuromuscular model
M63	Yili Zhang, Jorge Golowasch
	Modeling Recovery of Rhythmic Activity: Hypothesis for the role of a calcium pump
M64	Pierpaolo Pani, Giovanni Mirabella, Maurizio Mattia, Paolo DelGiudice, Stefano Ferraina
	Neural bases of context dependent reaction times in the dorsal premotor cortex of monkey
M65	Bart Sautois, Steve Soffe, Wen-Chang Li, Alan Roberts
	Modelling the spinal cord and behaviour of the frog tadpole
M66	Rafal Bogacz, Kevin Gurney, Tobias Larsen
	The brain implements optimal decision making mechanisms
M67	Leonid Rubchinsky, Karen Sigvardt
MO	Dynamics of Basal Ganglia-Thalamocortical Networks and Parkinsonian Tremor
M68	Lars Omlor, Martin A. Giese
	Extraction of spatio-temporal primitives of emotional body expressions
Sensory	systems
M69	Gary Marsat, Gerald S Pollack
11109	Sensory coding and burst firing: a behavioral link.
M70	Emili Balaguer-Ballester, Susan Denham
-	Auditory system time series analysis for both global pitch perception and harmonic segregation
M71	Martin Coath, Susan Denham
	The role of onsets in auditory processing.
M72	Hamish Meffin, Benedikt Grothe
	The modulation of spike rate in the dorsal nucleus of the lateral lemniscus by a virtually moving sound source
M73	Patrick Roberts, Roberto Santiago, Claudio Mello, Tarcisco Velho
	Storage of Auditory Temporal Patterns in the Songbird Telencephelon

M74	Christina Weaver, Susan Wearne
M75	Sensitivity analysis of neuronal firing to morphologic and spatially extended intrinsic properties Sayan Pathak, Christopher Lau, Lydia Ng, Leonard Kuan, Edward Lein, Michael Hawrylycz
M76	<i>3D mouse brain gene expression visualization and image-based genomic-level expression search</i> Fabio Simoes de Souza, Gabriela Antunes
WI / 0	Investigating the properties of adaptation in a computational model of the olfactory sensory neuron
M77	Amir Madany Mamlouk, Elena Schuh, Thomas Martinetz Olfactory Perception: Correlating Phylogenetic and Psychophysical Information
M78	Ondrej Pokora, Petr Lansky
	Optimal signal in ligand-receptor models
M79	Malin Sandström, Jeanette Hellgren Kotaleski, Anders Lansner
	Scaling effects in a model of the olfactory bulb
M80	Upinder Bhalla, Rinaldo D'Souza, Kalyanasundaram Parthasarathy
M81	An electrode's eye view of the rat olfactory bulb: using recordings and modeling to make a map Alla Borisyuk, David Terman, Brian Smith, Xueying Wang, Sungwoo Ahn, Jeong-Sook Im
	Clustering in a model of an insect antennal lobe
M82	Thomas Voegtlin, Dominique Martinez
M92	Effect of Asynchronous GABA Release on the Oscillatory Dynamics of Inhibitory Coupled Neurons
M83	Amir Madany Mamlouk, Martin Haker, Thomas Martinetz Perception Space Analysis: From Color Vision to Olfaction
	rereepiton space rinarysis. From Color vision to Organion
Informa	tion Coding II
M84	Yutaka Sakaguchi, Shiro Ikeda
	Motor Planning and Sparse Motor Command Representation
M85	Thomas Cleland, Brett Johnson, Michael Leon
MOG	Glomerular computations for normalization in the olfactory bulb
M86	Lubomir Kostal, Petr Lansky, Jean-Pierre Rospars
M87	Pheromone plumes provide optimal signal for the olfactory sensory neuron Hans Liljenström, Yuqiao Gu, Jean-Pierre Rospars
1010/	Cross-scale Neurodynamical Odour Coding and Its Modulation
M88	Aurel Lazar
	Information Representation with an Ensemble of Hodgkin-Huxley Neurons
M89	Vladislav Volman, Eshel Ben-Jacob, Herbert Levine
	Astrocyte modulation of synaptic transmission - autapse as a case study
M90	J-Olivier Coq, Céline Rosselet, Christian Xerri, Jean-Luc Blanc
	Neural population information related to localization versus feature extraction of complex stimuli
M91	Rasmus Petersen, Marcelo Montemurro, Stefano Panzeri, Miguel Maravall Coding By Precise Timing In The Somatosensory Thalamus
M92	Karim Oweiss, Rong Jin, Yasir Suhail
10172	Identifying neuronal assemblies with local/global connectivity with scale space spectral clustering
M93	Rasmus Petersen, Marco Brambilla, Miguel Maravall, Stefano Panzeri, Marcelo Montemurro
	Spike-Triggered Covariance Analysis Of Neuronal Responses To Dynamic Whisker Stimulation
M94	Laurent Perrinet
	An efficiency razor criteria for model selection and adaptation in the primary visual cortex
M95	Luis Lago-Fernández
MOC	Spike alignment in bursting neurons
M96	Marcel Stimberg, Thomas Hoch, Klaus Obermayer The Effect of Background Noise on the Precision of Pulse Packet Propagation in Feed-Forward Networks
M97	Si Wu, Sheng Li
	Robust Coding and Its Implication on Neural Information Processing
Function	nal Imaging and EEG
M98	Stepan Kruglikov, Sharmila Chari, Paul Rapp, Steven Weinstein, Barbara Given, Steven Schiff
1 (00	Fully Optimized Discrimination of Physiological Responses to Auditory Stimuli
M99	Peter Andras, Thomas Wennekers
M100	Pattern Languages and Stochastic Interaction in Neural Systems Paluh Major, Arvind Kumor, Androes Schulze Penhage, Ad Aartson
MIUU	Ralph Meier, Arvind Kumar, Andreas Schulze-Bonhage, Ad Aertsen Comparison of Dynamical States of Random Networks with Human EEG
M101	Eckehard Olbrich, Thomas Wennekers
	Dynamics of parameters of neurophysiological models from phenomenological EEG modelling
M102	Eckehard Olbrich, Peter Achermann
	Effect of sleep deprivation on oscillations in the human sleep EEG
M103	Yiu Fai Sit, Risto Miikkulainen
	A Computational Model of the Signals in Optical Imaging with Voltage-Sensitive Dyes

activity

M104 Won Sup Kim, Seung Kee Han

Spatiotemporal Phase Pattern Analysis of Alpha Desynchronization in Spontaneous Human EEG
 M105 Jeremy Caplan, Mackenzie Glaholt, Anthony R. McIntosh

Human theta oscillations associated with effective study of structured information

# **Tuesday Poster Session**

### **Hippocampus**

Hippoca	ampus
T1	Paulo Aguiar
	Hippocampal place cells and coding through constellations of active neurons
T2	Erick Chastain, Yanxi Liu
	Quantified Symmetry for Entorhinal Spatial Maps
Т3	Joe Monaco, I.A. Muzzio, L. Levita, Larry Abbott
	Entorhinal Input and Global Remapping of Hippocampal Place Fields
T4	Ricardo Chavarriaga, Denis Sheynikhovich, Thomas Strösslin, Wulfram Gerstner
	A feed-forward model of spatial and directional selectivity of hippocampal place cells
T5	Mathias Franzius, Henning Sprekeler, Laurenz Wiskott
	Slowness leads to Place Cells
T6	Adam Johnson, Neil Schmitzer-Torbert, Paul Schrater, David Redish
	Neural representations underlying learning and memory: critical analysis for experimental data
T7	Tyler Netherland, Jeffrey McKinstry
	Testing the SOCRATIC model of the hippocampus for sequence storage and recall
T8	Kit Longden
	In supports place field formation in a model of the cortical pathway to CA1
T9	Theoden Netoff, Tilman Kispersky, John White
	Imaging epileptiform activity in brain slices of entorhinal cortex and hippocampus
T10	Eleftheria Kyriaki Pissadaki, Panayiota Poirazi
	Modulation of excitability in CA1 pyramidal neurons via the interplay of EC and CA3 inputs
T11	Andras Lorincz, Takacs Balint
	Two-phase comparator model of the entorhinal cortex hippocampal loop forms realistic activity map
T12	Andras Lorincz, Takacs Balint
	Simple conditions for forming triangular grids
T13	William Levy, Ashlie Hocking
	Theta-Modulated Input in a Hippocampal Model with Intrinsic Gamma Oscillations
Synchro	onization and Oscillation
T14	Simona Cocco
	Persistence of activity in an isolated neuron
T15	Staude Benjamin, Stefan Rotter, Sonja Gruen
	Models of Correlated Poisson Processes: Rate Covariance and Spike Coordination
T16	Michiel Berends, Quinten Robberechts, Erik De Schutter
	Properties of the cerebellar Golgi cell and implications for network behaviour
T17	Eugene M. Izhikevich
11,	Computation With Spikes
T18	Tom Tetzlaff, Stefan Rotter, Ad Aertsen, Markus Diesmann
110	
T10	Time scale dependence of neuronal correlations
T19	Balázs Ujfalussy, Mihály Hajós, Tamás Kiss, Peter Erdi
	Theta synchronization in the medial septum and the role of the recurrent connections.
T20	Roberto Fernández-Galán, Bard Ermentrout, Nathaniel Urban
	Reliability and stochastic synchronization in type I vs. type II neural oscillators
T21	Jesus M Cortes, B. Wemmenhove, Joaquin Torres, J. Marro, H. J. Kappen
	Neural Automata: the effect of microdynamics on unstable solutions
T22	Mahmut Ozer, Muhammet Uzuntarla
	Effect of the sub-threshold periodic current forcing with noise on the synchronization of neuronal spiking
T23	Ändrey Shilnikov, Paul channell, Gennady Cymbalyuk
-	Applications of the Poincar\'e mapping technique to analysis of spike adding
	Approximations of the London ( Comparing to contraine to analysis of optice analysis
System	Dynamics II
T24	Dragos Calitoiu
1 - 1	The computation of the vulnerable phase in a model of Hodgkin-Huxley neuron
T25	Christopher Glaze, Todd Troyer
123	
T <b>2</b> (	A Synfire Chain Model of Zebra Finch Song
T26	Ruben Moreno-Bote, Nestor Parga
<b>T27</b>	Populations of cortical neurons in the high conductance state: steady state and transient behaviours
T27	Tjeerd Olde Scheper
	Emergent dynamic behaviour in rate controlled chaotically driven neuronal models

Emergent dynamic behaviour in rate controlled chaotically driven neuronal models

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T28	Joanna Pressley, Todd Troyer
	Voltage Distributions of Stochastic Integrate-and-Fire Neurons Move in a Low Dimensional Space
T29	Steven Schiff, Xiaoying Huang, Jian-Young Wu
	Spatiotemporal Organization of Cortical Dynamics
T30	Simei Wysoski, Lubica Benuskova, Alessandro Villa, Nikola Kasabov
	Hierarchical neurogenetic model of LFP generation: from genes to neural oscillations
Netwo	rk Properties
T31	Margarita Zachariou, Stephen Coombes, Rob Mason, Markus Owen
151	The Effect of Cannabinoids on Sensory Gating : a Neural Network Model Study
T32	Ullrich Bartsch, Daniel Durstewitz
152	Dopamine modulates slow frequency oscillations and coherence in a prefrontal cortex network model
Т33	Carmen Canavier, Selvakumar Selandipalayam
155	Predicting the Existence and Stability of 2P Modes in 2 Neuron Networks From Phase Resetting Curves
T34	Santi Chillemi, Michele Barbi, Angelo Di Garbo
151	Phase locking states of a pair of coupled inhibitory interneurons
T35	Guido Gigante, Paolo DelGiudice, Maurizio Mattia
100	Bursting and global oscillations in networks of adapting spiking neurons
T36	Johannes Hjorth, Alex Henna Elias, Jeanette Hellgren Kotaleski
	The significance of gap junction location in fast spiking interneurons
T37	Birgit Kriener, Ad Aertsen, Stefan Rotter
	Dale's principle and the formation of spatio-temporal activity patterns
T38	Reinoud Maex
	Dynamics of networks of electrically coupled neurons
T39	Sorinel Oprisan, Ana Oprisan
	Oscillatory patterns in networks of asymmetrically coupled neurons using phase response curve
T40	Nikola Venkov, Stephen Coombes
	Amplitude equations for a class of neural field models
T41	Tayfun Gürel, Luc De Raedt, Stefan Rotter
	NeuronRank for Mining Structure-Activity Relationships of Biological Neural Networks
T42	Mark Humphries, Kevin Gurney
	A means to an end: validating models by fitting experimental data
T43	Frances Skinner
	Toward direct links between model networks and experimental data
T44	Itsaso Olasagasti, Mark S. Goldman
T 46	A methodology for tuning nonlinear network models of parametric working memory
T45	Kanaka Rajan, Larry Abbott
T46	Controlling Network Dynamics
140	Joel Chavas, Nicolas Brunel Empirical lower bound of the number of fix points of an attractor neural network
T47	Anna Levina, Udo Ernst, Michael Herrmann
14/	Criticality of Avalanche Dynamics in Adaptive Recurrent Networks
T48	Mikael Huss, Martin Rehn
140	Tonically driven and self-sustaining activity in the lamprey hemicord: when can they co-exist?
T49	Douglas Baxter, John Byrne
1.0	Short-Term Plasticity in a Computational Model of the Tail-Withdrawal Circuit in Aplysia
T50	Robert Calin-Jageman, Paul S Katz, William N Frost
	Neuromodulatory control of rhythmic neural activity in the Tritonia swim central pattern generator
T51	Alberto Mazzoni, Elzabeth Garcia-Perez, Frederic Broccard, Paolo Bonifazi, Vincent Torre
	Burst dynamics in the spontaneous activity of an invertebrate neuronal network
T52	Wood Ric, Humphries Mark, Overton Paul, Stewart Robert, Kevin Gurney
	Selection in a model of striatum with fast spiking interneurons
T53	Jonathan Peelle, Vogels Vogels, Larry Abbott
	Temporal relationships between cell pairs in integrate-and-fire networks
T54	Yong Sook Goo, Jang Hee Ye, Je Hoon Seo
	Abnormal Retinal Spikes in Retinal Degenerate Mouse (rd mouse) Recorded with Multielectrode Array
T55	Kosuke Hamaguchi
	Mean Field Analysis of Mexican-hat type Neural Network with Leaky Integrate-and-Fire Neurons
T56	Richard Gray, Peter Robinson, Candy Fung
	Stability Constraints on Networks of Brain Components
T57	Ruth Durie, Gareth Leng, David Willshaw
<b>T</b> . <b>5</b> 0	A Population Model of Generation of Vasopressin Release
T58	Anastasia Tsingotjidou, Lazaros Iliadis, Christos Batzios, Georgios C. Papadopoulos
	A neural network approach of the sheep milk-ejection reflex

A neural network approach of the sheep milk-ejection reflex

	Poster Sessions
Cerebel	lum
T59	Fernando Fernandez, Raymond Turner
	Dynamics of first spike latency with and without A-type currents: implications for cerebellar Purkinjecell spike firing dynamics
T60	Naoki Masuda, Shun-ichi Amari
	Modeling memory transfer in cerebellar vestibulo-ocular-reflex learning
T61	Yutaka Hirata, Kayichirou Inagaki, Pablo Blazquez, Stephen Highstein
	Model of VOR motor learning with spiking cerebellar cortical neuronal network
T62	Werner Van Geit, Erik De Schutter
	Long-range dependence in spike trains recorded from cerebellar Purkinje cells
T63	Dieter Jaeger, Volker Steuber
	Comparison of DCN neuron rebound firing between in vivo and in vitro conditions: A modeling study
<u>Cortex</u>	
T64	Paul Adams, Kingsley Cox, Anca Radulescu
	The Neocortex as a Hebbian Proofreader
T65	Thomas Wennekers
	Cell assembly model for complex behaviour
T66	Andreas Knoblauch, Rüdiger Kupper, Marc-Oliver Gewaltig, Ursula Koerner, Edgar Koerner
	A cell assembly based model for the cortical microcircuitry
T67	Nicole Voges, Ad Aertsen, Stefan Rotter
	Anatomy-based network models of cortex and their statistical analysis
T68	Esther Gardner, Eric J. Lang, Adam Sherwood
	The Neuroinformatics Digital Video Toolkit (NIDVTK)
T69	Jens Kremkow, Arvind Kumar, Stefan Rotter, Ad Aertsen
	Population synchrony generation in a layered network of the cat visual cortex
T70	Antonio Pazienti, Sonja Gruen
	Impact of spike sorting errors on higher-order correlations
T71	Gordon Pipa, Alexa Riehle, Sonja Gruen
	NeuroXidence: Cross-validation of task related Joint-spike activity reported by Riehle et al. (1997)
T72	Emilio Kropff, Alessandro Treves
	Dynamics of latching in Potts models of large scale cortical networks
T73	Philip Ulinski
	Analyzing the Stability of Turtle Visual Cortex Using Lyapunov Functions for Non-autonomous Systems
T74	Misha Ahrens, Liam Paninski, Rasmus Petersen, Maneesh Sahani
	Input nonlinearity models of barrel cortex responses
T75	Andrew Davison, Pierre Yger, Jason Chan, Fiona Newell, Yves Frégnac
	A combined psychophysicalmodelling investigation of the mechanisms of tactile picture perception
T76	Gustavo Deco, Edmund Rolls
	Decision-Making and Weber's Law: Finite Size Fluctuations in Spiking Dynamics
D1 (* *	
Plastici	
T77	Lubica Benuskova, Nikola Kasabov
<b>T7</b> 0	Modeling L-LTP by means of changes in concentration of CREB transcription factor
T78	Fleur Zeldenrust, Michiel Remme, Wytse Wadman
T70	Homeostatic Scaling of Excitability in a Neuron with Spike Timing-Dependent Plasticity.
T79	Abigail Morrison, Ad Aertsen, Markus Diesmann
T00	Spike-timing dependent plasticity in balanced random networks
T80	Thomas Trappenberg, Dominic Standage Probabilistic, weight-dependent STDP leads to rate-dependent synaptic fixed points
т01	
T81	Hamish Meffin, Anthony Burkitt, Julien Besson, David Grayden Learning the structure of correlated synaptic subgroups using stable and competitive STDP
т <b>0)</b>	Steve Womble
T82	Homeostatic regulation of neuronal excitability, correlated patterns and global attractors
Т83	Krisztina Szalisznyo, Janos Toth
165	Temporal order of synaptic filters: implications for $F > D$ or $D > F$ processes
T84	Javier Iglesias, Alessandro E.P. Villa
104	Stimulus-Driven Synaptic Pruning and Spatio-Temporal Patterns of Activity in Large Neural Networks
T85	
T85	Markus Butz, Gertraud Teuchert-Noodt, Prof. Dr. Dr. Swantogenesis and neurogenesis are related phenomena in the adult deptate averus of gerbils
т94	Synaptogenesis and neurogenesis are related phenomena in the adult dentate gyrus of gerbils Hildur Eingradóttir, Simon P. Schultz
T86	Hildur Einarsdóttir, Simon R Schultz
T87	Is receptive field plasticity after a stroke-like lesion optimized for the preservation of topograph Kazuhisa Fujita, Yoshiki Kashimori
10/	Roles of short-term synaptic plasticity in electrosensory perception under competing sensory signals
T88	Jonathan Drover, Vahid Tohidi, Amitabha Bose, Farzan Nadim
100	Combining synaptic and cellular resonance in a feed-forward neuronal network
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- T89 Lian Zhou, Shunbing Zhao, Farzan Nadim
- Neuromodulation of short-term synaptic dynamics examined in a mechanistic model T90 Kenneth Harris
- Neural network learning through trophic interactionTomas Kulvicius, Bernd Porr, Florentin Woergoetter
- Tomas Kulvicius, Bernd Porr, Florentin Woergoetter
  Development of receptive fields in a closed loop behavioral system
  Yihwa Kim, Stefano Fusi, Walter Senn
- Formation of non-additive cortical object representations
- T93 Andreea Lazar, Gordon Pipa, Jochen Triesch
- Dynamics and robustness of recurrent spiking networksT94James Bednar, Christopher Ball
- Motion Aftereffects in a Self-Organizing Model of the Primary Visual Cortex

# Workshop abstracts

# Phase Response Curves: Where theory and experiments intersect

Organizers: Theoden (Tay) Netoff & Horacio G. Rotstein

### Speakers:

Robert Butera (Georgia Institute of Technology, GA) (Joint work with Amanda Preyer). *Title: Weak coupling and neuronal oscillators - is it valid and is it relevant?* 

Abstract: Many theoretical studies in computational neuroscience utilize phase oscillator models and the assumptions of weak coupling. While most modern approaches are based upon the work of Kuramoto (1984), the fundamental assumptions were put forth earlier by Winfree (1967). Here we review some recent work of ours (Preyer and Butera, 2005) where we validate the weak coupling assumption in the context of phase response curves and small perturbations to repetitively spiking neurons. We applied weak stimuli to neuronal oscillators in Aplysia californica and deconvolved infinitesimal phase response curves (IPRCs) that describe the phase response of a neuron. We show that these IPRCs reliably predict the phase response for weak stimuli, independent of the stimulus waveform used. These weak stimuli are in the range of normal synaptic activity for these neurons, suggesting that weak coupling is a likely mechanism. However, this work was done solely using PRCs, and not in the context of a real or artificial (dynamic clamp) network.

### Carmen C. Canavier

Title: Phase Resetting: Phenomenology and Applications.

Abstract: Phase resetting theory assumes that coupled oscillators continue to traverse their intrinsic limit cycles when coupled in a pulsatile fashion, except that the inputs received can advance or delay the progress on that limit cycle. This assumption is quite accurate for Type I oscillators that arise from a saddle node bifurcation. It is not so accurate for Type II oscillators (Hopf bifurcation) or for relaxation oscillators. However, as long as the trajectory of each component oscillator returns to near the limit cycle between inputs, the phase resetting curve (PRC) can be used to predict the patterns that will be produced by the coupled oscillators. One further assumption is required, that the input received in the closed loop is similar to the input with which the PRC was generated. The AB/PD complex is the main oscillator in the pyloric circuit of the stomatogastric ganglion of the lobster. It's response to inhibitory pulses can be predicted by presuming that it is a relaxation oscillator with a single slow variable (Oprisan et al 2003). An inhibition switches the trajectory in a normal direction between the depolarized and hyperpolarized branches of the limit cycle, and prevents a transition to the depolarized branch during its duration. Recent work shows that the response to an excitatory pulse is more complex. The inhibitory PRCs were successfully used to predict phase-locking in a circuit composed of the AB/PD complex coupled to a model neuron via the Dynamic Clamp (Oprisan et al 2004). One reason that it is important to understand the phenomenology of resetting in bursting neurons is that the coupling may truncate or elongate the burst, so that a PRC generated using the intrinsic burst duration of the presynaptic neuron may be inadequate for prediction purposes without better understanding of the phenomenology.

Roberto Fernández Galán (Joint work with G. Bard Ermentrout and Nathaniel N. Urban) *Title: Phase-response curves: predicting network dynamics from a single cell feature.* 

Abstract: The knowledge of the phase response permits us to reduce the complex dynamics of N real neurons to simple phase-oscillator models with N coupled, first-order differential equations. This enables efficient and fast simulations of large network models as well as their analytical treatment. Recently, several authors have proposed complementary methods of estimating the phase response in real neurons. I have used some of these techniques to build a simple, but realistic dynamical model of a real neuronal network (the olfactory bulb) that predicts the formation of synchronized neural assemblies in the gamma band. I will also show how these dynamics can be used to encode and discriminate odors. Finally, I will show the role of the phase response in spike-timing reliability and stochastic synchronization.

Mate Lengyel (GATSBY, UCL, UK) Title: TBA

Theoden Netoff (Boston University, MA) (Joint work with Lisa Giacomo and John A. White) *Title: Mechanisms of Carbachol oscillations*.

Abstract: Carbachol (CCh) is a cholinergic agonist that causes spontaneous theta frequency oscillations in the entorhinal cortex and hippocampus. To better understand the mechanism by which these oscillations are generated, we measured the effect of CCh on phase response curves from pyramidal neurons and stellate cells in the entorhinal cortex. Based on the measurements, it was predicted that CCh would facilitate synchronization of a network of pyramidal neurons but would have little or even a desynchronizing effect on stellate cells. The pyramidal cell results were then confirmed by coupling pairs of pyramidal neurons using the dynamic clamp and measuring their synchrony in control and CCh conditions.

Bart Sautois (Ghent University, Belgium) *Title: Phase response curves, delays and synchronization.* 

Abstract: Phase response curves, delays and synchronization MatCont is a Matlab software package for the study of dynamical systems through continuation and bifurcation analysis. We have developed a new and very fast way to compute PRCs as a byproduct of a continuation algorithm. We found that delays can be crucial for the synchronizing abilities of networks of neurons through excitatory connections. Using the PRC of a neural model, one can quickly compute the necessary delay to allow synchronization or phase locking.

Ruedi Stoop (Institute of Neuroinformatics, Zurich, Switzerland) Title: TBA

# Functional Models of the Hippocampal Formation

Workshop organized by Laurenz Wiskott

This workshop is an attempt to bring together different perspectives on the functional role and organizational principles of the hippocampal formation. It is planned to have talks of 25 minutes each with 15 minutes discussion time, so that there is plenty of opportunity for an exchange of ideas and questions. All the following speakers have confirmed their participation: Szabolcs Káli (Institute of Experimental Medicine, Hungarian Academy of Sciences, Budapest, Hungary)

Máté Lengyel (Gatsby Computational Neuroscience Unit, University College London, United Kingdom) "Firing rates and phases in the hippocampus: what are they good for?"

William B. Levy (Laboratory of Systems Neurodynamics, University of Virginia, Virginia)

András Lörincz (Department of Information Systems, Eötvös Loránd University, Budapest, Hungary) "May the hippocampal formation break the curse of dimensionality?"

The two-phase computational model of the entorhinal cortex - hippocampal (EC-HC) loop of Lorincz and Buzsaki is extended by a neural Kalman-filter model and by novel indepedendent process analysis neural architectures that perform noise filtering and can break combinatorial explosion together. Several falsifying predictions of the Lorincz and Buzsaki model have been reinforced experimentally after those predictions were made. The new model elaborates those predictions and offers a computational explanation for the crucial top-down supervisory-like role of this loop. Realistic robot simulations in a U-shaped and circular labyrinths are in progress. Prelimiary results concerning neural responses at the superficial and deep layers of the EC as well as at the CA1 subfield of the HC show good agreement with the experiments.

Roger Traub (Department of Physiology and Pharmacology, Suny Downstate Medical Center, Brooklyn, New York) "Electrical coupling between principal cell axons: a source of very fast oscillations (>70 Hz), gamma oscillations (30-70 Hz), and beta2 oscillations (20-30 Hz)"

A variety of experimental evidence supports the existence of gap junctions between principal cell axons, with ultrastructural confirmation being actively pursued. Both experimental and modeling evidence indicate that a network of electrically coupled axons can generate very fast oscillations, by a process resembling percolation on a random graph. Very fast oscillations in a pyramidal cell axonal plexus can in turn lead to gamma oscillations, in the presence of synaptic inhibition, an idea experimentally supported in the hippocampus, neocortex and entorhinal cortex. Finally, a newly discovered beta2 network oscillation occurs in parietal cortex in vitro, confined to large layer 5 pyramidal cells, that does not require chemical synapses, but does require gap junctions. The relevant electrical coupling in beta2 also appears to be axonal, although the morphological substrate remains to be identified.

Alessandro Treves (SISSA-Cognitive Neuroscience, Trieste, Italy) "What is the advantage of differentiating CA1 from CA3?"

Laurenz Wiskott (Institute for Theoretical Biology, Humboldt-University Berlin, Germany) "From slowness to place fields"

We present a model for the self-organized formation of hippocampal place cells based on unsupervised learning on natural visual stimuli. Our model consists of a hierarchy of Slow Feature Analysis (SFA) modules, which were recently shown to be a good model for the early visual system. The system extracts a distributed representation of position, which is transcoded into a place field representation by sparse coding (ICA). We introduce a mathematical framework for determining the solutions of SFA, which accurately predicts the distributed representation of computer simulations.

## Continuous Attractor Neural Networks

Organizers: Si Wu (University of Sussex, UK) and Thomas Trappenberg (Dalhousie University, Canada)

CANNs are a special type of recurrent networks that have been studied in many neuroscientific areas such as modelling hypercolumns, working memory, population coding and attention. Such neural field models of the Wilson-Cowan type, or bump models, are a fundamental type of neural networks that have many applications in neuroscientific modelling and engineering. The goal of this workshop is to bring together researchers from diverse areas to solidify research on CANNs including their theoretical underpinning and practical application.

We anticipate 20 minutes talks that will summarize research work with CANNs followed by a discussion of outstanding topics. The following persons have tentatively offered contributions

Gregor Schoner (Bochum, Germany), motor preparation and working memory Eric Sauser (Lausanne, Swizerland) movement generation Martin Giese (Tubingen, Germany) recognition of biological motion Michael Herrmann (Göttingen, Germany) symmetry breaking in a two dimensional Continuous Attractor Neural Network Kukjin Kang (RIKEN, Japan) orientation selectivity Nicolas Rougier (Villers les Nancy, France) attention Peter Latham (Gatsby Computational Neuroscience Unit, UK) population coding Kosuke Hamaguchi (RIKEN, Japan) correlation structure in CANN Thomas Wennekers (Plymouth, UK) spatio-temporal neural field approximation Zhaoping Li (London, UK) oscillation attractor Hiroshi Okamoto (RIKEN, Japan) information retrieval

## Methods of Information Theory in Computational Neuroscience

Organizers: Aurel A. Lazar, Department of Electrical Engineering, Columbia University and Alex Dimitrov, Center for Computational Biology, Montana State University.

Methods originally developed in Information Theory have found wide applicability in computational neuroscience. Beyond these original methods there is a need to develop novel tools and approaches that are driven by problems arising in neuroscience.

A number of researchers in computational/systems neuroscience and in information/communication theory are investigating problems of information representation and processing. While the goals are often the same, these researchers bring different perspectives and points of view to a common set of neuroscience problems. Often they participate in different fora and their interaction is limited.

The goal of the workshop is to bring some of these researchers together to discuss challenges posed by neuroscience and to exchange ideas and present their latest work.

The workshop is targeted towards computational and systems neuroscientists with interest in methods of information theory as well as information/communication theorists with interest in neuroscience.

Invited Presentations/Speakers

Lossy Compression in Neural Sensory Systems: At what Cost (Function)? Alex Dimitrov, Center for Computational Biology, Montana State University.

Biological sensory systems, and more so individual neurons, do not represent external stimuli exactly. This obvious statement is a consequence of the almost infinite richness of the sensory world compared to the relative paucity of neural resources that are used to represent it. Even if the intrinsic uncertainty present in all biological systems is disregarded, there will always be a many-to-one representation of whole regions of sensory space by indistinguishable neural responses. When noise is included, the representation is many-to-many. One direction of research in sensory neuroscience, espoused by us and others, is to identify and model such regions, with the goal of eventually completely describing neural sensory function as the partitioning of sensory space into distinguishable regions, associated to different response states of a sensory system. In essence, our goal is to quantify the distortion function of a particular biological system. In pursuing this agenda, the vastness of sensory space imposes a certain style of analysis that explicitly addresses the problem ensuing from the availability of relatively small datasets with which to provide description of relatively large sensory regions. We report our progress in this direction.

Estimating Mutual Information by Bayesian Binning Dominik Endres, School of Psychology, University of St Andrews.

I'll present an exact Bayesian treatment of a simple, yet sufficiently general probability distribution model, constructed by considering piecewise constant distributions P(X) with uniform (2nd order) prior over location of discontinuity points and assigned chances. The predictive distribution and the model complexity can be determined completely from the data in a computational time that is linear in the number of degrees of freedom and quadratic in the number of possible values of X. Furthermore, exact values of the expectations of entropies and their variances can be computed with polynomial effort. The expectation of the mutual information becomes thus available, too, and a strict upper bound on its variance. The resulting algorithm is particularly useful in experimental research areas where the number of available samples is severely limited (e.g. neurophysiology).

Information Theory and Neuroscience

Don H. Johnson and Christopher J. Rozell, Department of Electrical Engineering, Rice University.

When Shannon developed information theory, he envisioned a systematic way to determine how much "information" could be transmitted over an arbitrary communications channel. While this classic work embraces many of the key aspects of neural communication (e.g., stochastic stimuli and communication signals, multiple-neuron populations, etc.), there are difficulties in applying his concepts meaningfully to neuroscience applications. We describe the classic information theoretic quantities---entropy, mutual information, and capacity---and how they can be used to assess the ultimate fidelity of the neural stimulus representation. We also discuss some of the problems that accompany using and interpreting these quantities in a neuroscience context. We also present an overview of post-Shannon research areas that leverage his work in rate-distortion theory that are extremely relevant to neuroscientists looking to understand the neural code. The presentation is meant to be mostly tutorial in nature, setting the stage for other workshop presentations.

#### An Exactly Solvable Maximum Entropy Model

Peter Latham, Gatsby Computational Neuroscience Unit, University College London.

One of our main goals in life is to dream up distributions that do a good job approximating neural data. One natural class of distributions are maximum entropy ones, a class with a great deal of aesthetic. Before applying these to real data, however, it would be nice to develop an understanding of their properties. This, however, is hard, mainly because for most correlated distributions even sampling is intractable, let alone doing anything analytic (the obvious exception, Gaussians, rarely occur in real life, something that is especially true for neural data). Fortunately, there's at least one correlated distribution for which we can calculate many things analytically; that model is what we investigate here. Our goal is twofold. First, we simply want to develop intuition for maximum entropy models. Second, we want to understand something about estimating these models from data, in particular whether results we get from a reasonably small number of neurons, say around 10, provide us with any information about what's happening when the number of neurons is large, on the order of 1000s or more.

Information Representation with an Ensemble of Hodgkin-Huxley Neurons Aurel A. Lazar, Department of Electrical Engineering, Columbia University.

Motivated by the natural representation of stimuli in sensory systems, we investigate the representation of a bandlimited signal by an ensemble of Hodgkin-Huxley neurons with multiplicative coupling. We show that such a neuronal ensemble is I/O equivalent with an ensemble of integrate-and-fire neurons with variable threshold. The value of the threshold sequence is explicitly given. We describe a general algorithm for recovering the stimulus at the input of the neuronal ensemble.

Some Interrelationship between Information, Information Processing, and Energy William B. Levy, Laboratory for Systems Neurodynamics, University of Virginia.

The talk will consider the development of quantitative predictions that arise when communication and information processing are constrained by efficient use of metabolic energy. Computation in brain is adiabatic. Information processing and communication use currents powered by ion gradients. Then, the Na-K ATPase pump expends metabolic energy to maintain these ion gradients via an unmixing process. Both ends of the process (computation and pumping) are essentially frictionless. The heat generated by brain comes from the inefficient conversion of glucose into ATP. Several ways that energy is used in brain can be surprising, particularly when compared to energy use in manufactured computers and communication equipment. Some examples will be discussed.

Attwell, D. & Gibb, A. Neurosci. 6, 2005, 841-849; Attwell, D. & Laughlin, S. B. J. Cerebral Blood Flow and Metabolism 21, 2001, 1133-1145; Crotty. P., Sangrey, T., & Levy, W. B J Neurophysiol, in press, 2006; Levy, W. B & Baxter, R. A. Neural Comp. 8, 1996, 531-543; Levy, W. B & Baxter, R. A. J. Neurosci. 22, 2002, 4746-4755; Levy, W. B, Crotty, P., Sangrey, T., & Friesen, O. J. Neurophysiol. 2006, in press; Sangrey, T. and Levy, W. B Neurocomputing 65-66, 2005, 907-913.

Real-time Adaptive Information-theoretic Optimization of Neurophysiological Experiments Jeremy Lewi, Robert Butera, and Liam Paninski, Department of Statistics, Columbia University.

Adaptive optimal experimental design is a promising idea for minimizing the number of trials needed to characterize a neuron's response properties in the form of a parametric statistical encoding model. However, this potential has been limited to date by severe computational challenges: to find the stimulus which will provide the most information about the (typically high-dimensional) model parameters, we must perform a high-dimensional integration and optimization in near-real time. Here we develop a fast algorithm, based on a Fisher approximation of the Shannon information and specialized numerical linear algebra techniques, to compute this optimal (most informative) stimulus. This algorithm requires only a one-dimensional linesearch, and is therefore efficient even for high-dimensional stimulus and parameter spaces; for example, we require just 10 milliseconds on a desktop computer to optimize a 100-dimensional stimulus, making real-time adaptive experimental design feasible. Simulation results show that model parameters can be estimated much more efficiently using these adaptive techniques than by using random (nonadaptive) stimuli. Finally, we generalize the algorithm to efficiently handle both fast adaptation due to spike-history effects and slow, non-systematic drifts in the model parameters.

Stefano Panzeri, Faculty of Life Sciences, University of Manchester.

Correlations, Synergy and Coding in the Cortex: an Old Dogma Learns New Tricks Simon R. Schultz, Department of Bioengineering, Imperial College. Recent results from a number of groups have revealed the "correlation = 0.2 in the cortex" dogma to be an over-simplification: with carefully constructed stimuli, inter-neuronal synchronization can depend upon stimulus properties in interesting ways. We have been using Information Theory to study the effect of this stimulus- dependent synchronization on the neural coding of orientation and contrast in V1. We analysed pairs of simultaneously recorded neurons in the macaque primary visual cortex, whose receptive fields were carefully mapped and co-stimulated. Direction coding showed weak synergistic effects at short timescales, trailing off to informational independence at long timescales. An information component analysis revealed that this was due to a balance of a synergistic contribution due to the stimulus-dependence of synchronization, with redundancy due to the overlap of tuning. In comparison, contrast coding was dominated by redundancy due to the similarity in contrast tuning curves and showed a weak synergy at only very short time scales (< 5 ms). Stimulus dependence of synchronization does therefore have an effect on coding - and its effect is to pull the coding regime back towards informational independence, when redundancy would otherwise rule due to (the possibly inevitable) effects of correlations and tuning overlap. Work performed in collaboration with Fernando Montani, Adam Kohn and Matthew Smith.

## Modelling structural plasticity and neural development

### M. Butz & A. van Ooyen

Structural plasticity in terms of neurite outgrowth, synapse formation, synaptic regression and turnover as well as neurogenesis and apoptosis is crucial for neural development during ontogeny and even for network reorganizations in the mature brain. During development, progressive and regressive events go hand-in-hand to form a homeostaically stable network structure. The workshop is in order to discuss the biological background as well as current theoretical approaches that shed a light to the dynamic of those morphogenetic processe. Besides very different theoretical as well as experimental talks (30 minutes) there will be plenty room for discussion (15 minutes after each talk)

Introduction :

Computational Neuroscience of Homeostatic PlasticityModeling activity-dependent network development by neurite outgrowth and synapse formation

Arjen van Ooyen, CNCR, Vrije Universiteit Amsterdam

#### Neurite outgrowth

Models for neurite outgrowth and branching. Bruce P. Graham, Edinburgh

The impact of dendritic morphology on the neuronal firing pattern Ronald van Eburg, CNCR, Vrije Universiteit Amsterdam

#### Synaptogenesis

Experimental data on structual reorganization â "lysosomal processes indicating a transneuronal reorganization in the avian brain Gertraud Teuchert-Noodt, Neuroanatomy, University of Bielefeld

Modelling structural plasticity â "experimental and theoretical data on hippocampal plasticity Markus Butz, Dept. of Neuroanatomy, University of Bielefeld

Cortical network development

Modelling a developing cortical connectivity. Marcus Kaiser, Newcastle Modelling structural plasticity in prefronto-cortical networks Markus Butz, Dept. of Neuroanatomy, University of Bielefeld

## Using Extracellular Recordings to Constrain Compartmental Models-Tutorial

#### Carl Gold

Koch Laboratory, Computation & Neural Systems, California Institute of Technology

It has recently been demonstrated that extracellular action potential (EAP) recordings not only contain significant information about the intracellular state of neurons, but they also provide an excellent source of data for tuning the parameters of compartmental models. (Gold et al., 2006, Journal of Neurophysiology) This may be particularly useful for modeling neurons in vivo, where extracellular recordings are the only data available. This method relies on the Line Source Approximation (LSA) to model the EAP voltage resulting from the spiking activity of individual neurons.

Because the method is relatively complex and not directly supported in the NEURON Simulation Environment we will release a public

version of the code used in (Gold et al., 2006). The tutorial will review the theory of the LSA, present results pertinent to the use of EAP recordings to tune compartmental models, make the first public distribution of the LSA source code, and support each participant in running a simulation and calculating the resultant EAP.

Participants who wish to run the simulations should bring their own laptop comuter with the NEURON Simulation Environment and Matlab installed.

## Neuro-IT workshop on Interoperability of Simulators

### Erik de Schutter

For quite some time *interoperability* of neural simulators has been considered an important goal of the community. But is this more than a buzz word? Is it possible/easy to transfer models from one simulator program to another? And how should this be solved? By making simulators interact with each other, which may be useful anyway to simulate multi-scale models by combining different specialized simulators, or by defining models in a simulator-independent way? This workshop brings together several outstanding simulator developers to present and discuss their views on the following 3 questions:

- one big simulator versus specialized simulators

- interoperability of specialized simulators

- simulator independent model specification

Most speakers will touch on several issues but they have been grouped by which topic they will emphasize

### PRELIMINARY PROGRAM

Wednesday July 19: Morning Session:

9.00 - 9.05 E. De Schutter (University of Antwerp, Belgium): Introduction

1. One big simulator versus or together with specialized simulators?

9.05 - 9.30 Joel R. Stiles (University Pittsburgh, USA): "Spatial Realism and Multiscale Issues for Physiological Simulations" 9.40 - 10.05 Upinder S. Bhalla (National Centre for Biological Sciences, Bangalore, India): "MOOSE/GENESIS 3: A general simulator with specialized, optimized solvers"

10.15 - 10.40 Stefan WIIs (University of Antwerp, BE): ""

10.50 - 11.10 Coffee break

11.10 - 11.35 Marc-Oliver Gewaltig (Honda Research Institute, Germany): "Simulator Interoperability from the perspective of NEST?"

2. Interoperability of specialized simulators

11.45 - 12.10 Fred Howell (University of Edinburgh, UK): "Pattern machines and spikes"

12.30 - 14.00 Lunch break

Afternoon Session:

14.00 - 14.25 Eilif Muller (University Heidelberg, Germany): "A better interpreter for computational neuroscience"

14.35 - 15.00 Hugo Cornelis (University Texas San Antonio, USA): "Accessibility of Neuronal Models using the Neurospaces Studio"

3. Simulator independent model specification

15.10 - 15.35 Padraig Gleeson (University College London, UK): "NeuroML for simulator independent model specification"

15.45 - 16.00 Coffee break

16.00 - 16.25 Mike Hines (Yale University, USA): "NEURON CellBuilder descriptions of inhomogenous channel density"

16.35 - 17.00 Robert Cannon (University of Edinburgh, UK): "Case studies in component specialization and model specification" 17.30 Closure

Thursday July 20:

Morning Session: 9.00 - 10.00 Short recapitulation of main points + response to reactions by speakers (5 min each) 10.00 - 10.50 Open discussion 10.50 - 11.10 Coffee Break 11.10 -12.00 Open discussion and conclusions

Supported by the European Commission (FP5-IST NeuroIT.net)

## Terminology and Metadata for Modeling and Computational Neuroscience

Date: We will convene on the morning of Wednesday, July 19 and break on the afternoon of Thursday, July 20, in time for late departures from Edinburgh airport or Waverley Station.

Organizer: Daniel Gardner, Weill Medical College of Cornell University, dgardner at med dot cornell dot edu

Co-organizer: David H. Goldberg, Weill Medical College of Cornell University, dhg2002 at med dot cornell dot edu

This by-invitation workshop is intended to advance computational neuroscience by devising, discussing, evaluating, and adopting metadata terms useful for linking experimental data and methods, theoretical models, and analytical insights. As part of a comprehensive terminology effort, the terms we adopt will also bridge computational neuroscience and other emerging areas of neuroinformatics. We plan an informal and productive working meeting; aside from brief introductions to this terminology effort, the Neuroscience Information Framework project, and the related UK CARMEN project, there will be no presentations.

The workshop will bring together a core group of experts in the acquisition, archiving, and analysis of neuroscience data, and in the development, testing, and application of models. Supplementing file format and other standards efforts, our goal includes terminology specific enough to describe neuroscience data, their acquisition and processing, along with significant details of study protocols, experimental procedures, and analytic methods. Other terminologies will classify models. Towards integration of data with models, we should derive as well more general descriptors that aid experimentalists and theoreticians to locate and leverage one another's work. Recognizing parallel efforts, the workshop will also consider what components of existing terminologies should be adopted—or adapted—toward our goals. Supporting interoperability, our terminologies will be integrated with other vocabularies derived at complementary workshops and provided freely via Open Source for wide adoption.

The work will aid development of the Neuroscience Information Framework, an open, comprehensive, dynamic, inventory of Webaccessible neuroscience resources, an extended and integrated BrainML terminology describing resources and contents, and a conceptbased query engine to span resources across multiple levels of biological function and provide rapid, informative, and clear responses.

This page provides a brief agenda; additional information and a worksheet will be provided about one week before the meeting. Aside from some brief introductions, there are no talks and no formality; we provide an enjoyable working session to characterize current research and plan for its evolution.

Introductions

Neuroinformatics, the Neuroscience Information Framework, and global links The UK's related CARMEN project Modeling and Computational Neuroscience as a prototype effort Immediate goals: model and technique descriptors, journal keywords Long-term goals: linking data, models, and analyses; facilitating knowledge bases and engines Controlled vocabularies and metadata One size does not fit all We will specify multiple descriptors, and arrange terms in hierarchic trees Terms requested should not be more than investigators can determine and supply We select terms useful for Modeling and Computational Neuroscience Build on existing NeuroML, BrainML, and Society for Neuroscience and Framework terms specified by prior workshops Identify classes needed now Project future data, technique, model, and analysis descriptors, and needed links to other systems Split into informal working groups to parallelize effort Working groups present initial vocabulary trees Thursday convergence: Refine, revisit, and revise vocabularies Evaluate for adoption related ontology efforts Establish mechanisms for evolution of controlled vocabularies Establish mechanisms for coordination with terminologies produced for other systems

## Cortical map development

#### Organizer James A. Bednar

Venue: Edinburgh, Scotland, currently scheduled for the morning of Wednesday, July 19th.

Computational models of cortical map development have been able to explain many experimental findings from visual and other sensory cortices, including columnar organization, receptive field properties, lateral and feedback connection patterns, and adult plasticity.

The talks and discussion in this workshop will provide a brief survey of existing and future map modeling approaches, examining:

- How to incorporate recent experimental results in models, such as highly detailed 2-photon imaging data, dramatic species differences in cortical maps, long-ranging map-specific feedback connections, and maps for color preference.
- How to extend map models to cover topics not well explained by current approaches, such as the laminar organization within each area, the development of multiple areas, non-visual modalities, and the integration of multiple sensory areas.
- How to differentiate between different models of the same phenomena, finding concrete predictions of each model that can be tested by experiment.

Other current topics related to cortical map development, or neural maps in general, are also very welcome.

Format: Informal mini-symposium. An overview talk and informal research and discussion-oriented talks from a series of speakers are planned, with questions and comments encouraged throughout.

## Cortical Microcircuitry

Recent years have brought a tremendous progress in unravelling anatomical and physiological properties of the cortical microcircuitry. Indeed, a large number of different cell-types is increasingly revealed to be engaged in the cortex into dense and complicatedly structured networks that span longitudinally through all cortical layers and extend laterally across distances of up to several millimetres in the cortical maps. Anatomical complexity is in addition paralleled by a rich intrinsic and stimulus-related dynamic repertoire. We are only at the beginning of an understanding of the observable complexity and its possible impact on cortical function. Still, there is the believe that despite its rich structure and dynamics, something like a ``prototypical cortical microcircuit" can be isolated, that repeats throughout the cortical areas and provides a core functionality capable to adapt to different requirements in different areas.

The present workshop brings together experts from experimental and computational neuroscience in order to review some of the ongoing experimental research concerning cortical microcircuitry as well as related theoretical concepts.

The workshop will span both afternoon sessions at the 19th/20th of July.

Each of the speakers has a 45 minutes slot split between presentation and discussion at his/her convenience.

19. July 2006		
14:00-14:45	Alex Thomson	Wiring diagrams and synaptic properties: What we know and what we don't know
14:45-15:30	Arnd Roth	Predicting synaptic connectivity from neuronal morphology
15:30-15:45	break	
15:45-16:30	tbc	
16:30-17:15	Mike Denham	Computational theories for the cortical microcircuit
20. July 2006		
14:00-14:45	Rolf Koetter	Mapping cortical microcircuitry by focal flash release of caged glutamate
14:45-15:30	Daniel Durstewitz	NMDA-driven recurrent dynamics and its implications for active memory
15:30-15:45	break	
15:45-16:30	Stefano Panzeri	Stimulus specificity of cortico-cortical connections optimizes information transmission
16:30-17:15	Thomas Wenneker	sOperational cell assemblies in large-scale cortex models

This workshop has been funded in part by the Engineering and Physical Sciences Research Council / UK as part of the COLAMN project (EPSRC grant EP/C010841/1)

# Synaptic plasticity and stability

Thursday 20, 9.00-12.00 Organizer: Mark van Rossum

Mark van Rossum. Introduction

Abigail Morrison Spike-timing dependent plasticity in balanced random networks

The balanced random network model attracts considerable interest because it explains the irregular spiking activity at low rates and large membrane potential fluctuations exhibited by cortical neurons in vivo. Here, we investigate to what extent this model is also compatible with the experimentally observed phenomenon of spike-timing dependent plasticity (STDP). Confronted with the plethora of theoretical models for STDP available, we re-examine the experimental data. On this basis we propose a novel STDP update rule, with a multiplicative dependence on the synaptic weight for depression, and a power law dependence for potentiation. We show that this rule, when implemented in large (100,000 neurons) balanced networks of realistic connectivity and sparseness (10,000 synapses per neuron), iscompatible with the asynchronous irregular activity regime. The resultant equilibrium weight distribution is unimodal with fluctuating individual weight trajectories, and does not exhibit spontaneous self-organisation of structure.

Stefano Fusi

Limits on the memory-storage capacity of bounded synapses

Memories, maintained in patterns of synaptic connectivity, can be over-written and destroyed by ongoing plasticity arising from the

### Workshop Abstracts

storage of new memories. Such overwriting leads to forgetting and memory lifetimes that are only proportional to the logarithm of the number of synapses being used to store the memories. This poor memory performance arises from imposing reasonable limits on the range of allowed synaptic efficacies because memories are destroyed when synapses reach the bounds

on their strengths. We explore whether memory performance can be improved by allowing synapses to traverse a large number of states before reaching their bounds, or by changing the way in which these bounds are imposed. In agreement with previous results, we find that memory lifetimes grow, in the case of hard bounds, proportional to the square of the number of levels of synaptic efficacy. However, this improvement requires a precise balance between the effects of potentiation and depression. Imposing soft bounds on synaptic efficacy improves memory performance when potentiation and depression are not balanced. In the generic case, without fine-tuning, memory lifetimes can only be improved by a factor that is linear in the number of states traversed by the synapse between the limits of its efficacy. (This work has been done with Larry Abbott.)

#### Peter Appleby

'Stability and spike-timing-dependent plasticity'

Many models of synaptic plasticity exist, including several based on the phenomenon of spike-timing-dependent plasticity (STDP). In their basic form, models of STDP are often unstable. Typically, this behaviour is suppressed by the introduction of additional constraints in the learning rule. Although successful, these constraints often introduce a considerable computational burden at the synaptic level. Is such an empirical approach always necessary? or is it possible to construct more natural models of STDP that are intrinsically stable?

#### Jean-Pascal Pfister

"Why Triplets of Spike are Necessary in Models of STDP?"

Classical experiments on spike-timing dependent plasticity (STDP) use a protocol based on *pairs* of pre- and postsynaptic spikes repeated at a given frequency in order to induce synaptic potentiation or depression. Therefore standard STDP models have expressed the weight change as a function of pairs of pre- and postsynaptic spike. Unfortunately, those paired-based STDP models cannot account for the dependence upon the repetition frequency of the pairs of spike. Moreover, those STDP models cannot reproduce recent triplet and quadruplet experiments. Here we examine a *triplet* rule, i.e. a rule which considers sets of three spikes (2 pre and 1 post or 1 pre and 2 post) and compare it to classical pair-based STDP learning rules. With such a triplet rule, it is possible to fit experimental data from visual cortical slices as well as from hippocampal cultures. Moreover, when assuming stochastic spike trains, the triplet learning rule can be mapped to a Bienenstock-Cooper-Munro learning rule.

#### Different models, same outputs Monday Poster-M58 Hippocampal place cells and coding through constellations of active neurons Pablo Achard Paulo Aguiar Tuesday Poster - T1 Erik De Schutter IBMC University of Antwerp, Wilrijk, Belgium Morphophysiology of the Nervous System, Porto, Portugal paguiar@ibmc.up.pt pablo@tnb.ua.ac.be erik@tnb.ua.ac.be The hippocampus is undoubtedly a pivotal structure in the mammal memory systems. Its primary role is, however, subject to strong debate as a consequence Small changes in the channel conductances of a neuron can lead to drastically different electrical activities. Nevertheless, robustness of activity to channel of the following two competing views: either the hippocampus is a general alterations, also called functional homeostasis, have been observed in several memory place for episodes, or the hippocampus is a specialized memory system experiments. Previous computational models have demonstrated that identical dedicated to spatial memory. The existence of ``place-cells" offers strong network or neuron activities could be obtained from disparate modeling support for the hippocampus' involvement in spatial mapping. Here it is shown parameters. However, these models had several limitations on the number of that the major properties of "place-cells" can be accounted for in a spiking free parameters as well as on the complexity and details of the output electrical hippocampal model which represents the hippocampus as a general memory activity. We will demonstrate that it is possible to obtain 20 computational place where multi-modal perceptual information is combined in the form of models of the highly complex Purkinje cell which are all very different from 'episodes". It is argued that space is a modulator of perceptual information, as is each other and all giving the same output to current injection, up to small details. time, but it is not the object of the storage process. The model shows that cells In addition, features for which the models were not tuned, i.e. their response to belonging to internal representations of relevant perceptual configurations, the synaptic input, were also very similar. We have tested several hypothesis that true objects of the associative memory mechanisms, exhibit the same basic can explain this model diversity. First, out of the 24 free parameters of the properties as place cells. Numerical simulations of the model show how models, 7 seem to have a very small effect on their behavior. manipulations in the input space, mimicking geometric manipulations, affect the However, a model with these 7 parameters set to zero and all other parameters behavior of constellation units. equal to the data value has a bad fitness value. Second, the models we found are not belonging to a continuum of good solutions. Third, we have searched for linear correlations between parameters. Only 5 pairs out of 276 have a probability to have null correlation below 1%. Fourth, the dispersion of the 20 Input nonlinearity models of barrel cortex responses Tuesday Poster – T74 models is less important if the same currents expressed in different physiological zones are summed up. Nevertheless this dispersion is still significant. We have Misha Ahrens then analyzed in more details the phase-space and found the following: regions Liam Paninski of good models surround our 20 solutions and often -but not always- link them Rasmus Petersen together. But around every good individual, a 5% difference in one of its Maneesh Sahani parameters only can lead to very bad models. The hypervolume delimitating good points are quite restricted to the hyperplanes defined by averages of our Gatsby Computational Neuroscience Unit original solutions. University College London, London, UK ahrens@gatsby.ucl.ac.uk liam@stat.columbia.edu The Neocortex as a Hebbian Proofreader Tuesday Poster - T64 Spike triggered average, or reverse correlation, techniques are widely used for Paul Adams characterizing response functions in sensory areas. In many cases, however, the Kingsley Cox linear model that results from this analysis does not accurately predict the Anca Radulescu spiking response of the sensory neuron, indicating that properties of the response function have been missed. A powerful alternative is spike triggered covariance Stony Brook University, Stony Brook, New York, USA analysis, which can be used to estimate a multidimensional linear-nonlinear (LN) model. In the present work we present a different approach, the "input nonlinearity" model (as opposed to the "output nonlinearity" LN model) which padams@notes.sunysb.edu kcox@syndar.org assumes that integration across stimulus dimensions, such as time, is linear; but is preceded by a non-linear transformation of the stimulus value. We present an The Neocortex as a Hebbian Proofreader: Kingsley Cox, Anca Radulescu and algorithm for finding the parameters of the model, including the form of the

Paul Adams Dept. Neurobiology, SUNY Stony Brook, NY 11790 USA We propose that the neocortex is a machine for learning high order correlations which avoids error catastrophes induced by relatively unstructured environments using an online Hebbian proofreading canonical microcircuit. We argue that there is inevitable crosstalk between individual weight updates, for example caused by spine-spine calcium spillover. This reflects the incompatible requirements for voltage spread and calcium localization in networks that use voltage to compute and calcium to learn; the ratio of their space constants sets a plasticity error level. We show that for linear neurons which only learn pairwise statistics such errors do not completely prevent self-organisation, although learning gets worse as the network enlarges. But if neurons are nonlinear (essential for learning high-order statistics), a learning error collapse occurs at a network size given by the reciprocal error rate, typically around 1 thousand. Since the cortex cannot know in advance what environments could trigger a collapse, and there are typically 1000 inputs to a column, it must use an independent online assessment of current input statistics to gate learning by feedforward networks, a form of Hebbian proofreading. We show that a microcircuit which guarantees catastrophe avoidance, and which would therefore allow the neocortex to act as a universal learning machine, closely resembles the physiology and anatomy of layer 6 cells and connections. Proofreading guarantees catastrophe avoidance at the expense of slowed learning. Supported by the Kalypso Institute.

input non-linearity, from data. We then apply it to responses in the rodent barrel cortex, evoked by a dynamic white-noise whisker deflection stimulus. This results in a significant increase in predictive power over the linear model, which essentially fails to capture any properties of the response function. Furthermore, by inspecting the best-fit model parameters, we find that the majority of the neurons are more responsive to the velocity than to the position or acceleration of the whiskers, and that direction tuning is weak for the dynamic stimulus.

# Categorical processing of continuously morphed natural images in inferotemporal cortex

Athena Akrami MondayPM Oral Yan Liu, Alessandro Treves,Bharathi Jagadeesh

Cognitive Neuroscience Sector, SISSA, Trieste, Italy

akrami@sissa.it liuyan@u.washington.edu

The selectivity of neurons in IT cortex for realistic images is thought to underlie the remarkable object recognition capabilities of primates, but the relationship between the responses of individual neurons and global object discrimination is poorly understood. We trained monkeys to perform a discrimination task with pairs of simple but realistic scenes, and simultaneously measured behavioral and neural response. Monkeys performed a delayed-match-to-sample task in which one of two sample stimuli was presented for 250 ms and followed, after a delay, by a pair of choice stimuli. The monkey picked the stimulus match from the pair with a saccade. We used pairs of images that spanned the tuning space of each neuron: one stimulus activated the cell and the other did not. We then manipulated the sample stimulus, by morphing 9 intermediate images between the two original ones. The fifth morph was thus halfway, and there was no correct response, but the monkey was still required to pick a match stimulus. We discarded data from 2/11 image pairs, for which the behavioral response was not a sigmoidal curve, and neuronal responses showed a jagged profile along the morphing dimension. With the remaining 9/11 pairs, monkeys distribute their responses smoothly from one sample choice to the other as the content of the sample is gradually transformed. Neuronal response mimics behavior. The selectivity between two symmetric morphs continuously decreases, as they approach one another. We compute neurometric curves, describing the choice of an ideal observer who sees the responses of single neurons over prescribed time windows. We find that responses are maximally discriminative at the extremes in the period 130-180 ms after stimulus onset; but during the delay they become sigmoidal, and from this short-term memory activity the extreme images cannot be better categorized than the intermediate morphs. (Support: Whitehall, McKnight, Sloan Foundations, NIH, Human Frontier SP)

#### A Scientific Document Management System for Neuroscience

Peter Andras Sunday Poster – S46 Hai Nam Ha

School of Computing Science, University of Newcastle upon Tyne, UK

peter.andras@ncl.ac.uk,h.n.ha@ncl.ac.uk

Scientists have to deal with continually increasing amounts of documents even in narrowly restricted areas of neuroscience. Automated management of such large amounts of document could help significantly the work of scientists. Here we present an automated document management system that uses selforganising maps and expert knowledge to organise scientific documents. We show how our system works in the context of a collection of papers about the stomatogastric ganglion. We also discuss how our system can be extended to become an Internet-scale scientific document management system.

#### Pattern Languages and Stochastic Interaction in Neural Systems

Peter Andras Monday Poster – M99 Thomas Wennekers

School of Computing Science, University of Newcastle upon Tyne, UK

peter.andras@ncl.ac.uk thomas.wennekers@plymouth.ac.uk

Recent experimental analysis shows that a large part of cortical neural activity is ongoing spontaneous activity which is present even in the absence of external stimuli. We analyzed high resolution EEG recordings by extracting an activity pattern language from the data at various time scales. We used stochastic interaction measures to analyze the extracted pattern languages. Our analysis indicates that indeed the extracted pattern languages are likely to represent underlying neural information processing dominated by internal processing

# Activation of CaMKII under different protocols of Ca2+ oscillations, mediated by PP2B, AC and PDE

Monday Poster – M32

Gabriela Antunes, AntÙnio Roque University of Sao Paulo, Ribeiro Preto, Brazil gabrian@usp.br, antonior@neuron.ffclrp.usp.br

Ca2+/calmodulin-dependent protein kinase II (CaMKII) is a multifunctional enzyme that is activated by binding calcium/calmodulin ((Ca2+)4CaM), followed by autophosphorylation, which maintain the enzyme activated even in the absence of (Ca2+)4CaM. Autophosphorylated CaMKII returns to its basal activity through the action of protein phosphatase 1 (PP1), a phosphatase regulated by several molecules. An important mechanism that controls this process is the activation of the cyclic adenosine monophosphate-dependent protein kinase (PKA), which phosphorylates the Inhibitor-1 (In-1) and determines the inhibition of the PP1. However, the dephosphorylation of In-1 by protein phosphatase calcineurin (PP2B) restores the action of PP1. A central fact on the control of this process is the action of (Ca2+)4CaM as the activator of PP2B, CaMKII, adenylyl cyclase (AC), and cyclic nucleotide phosphodiesterase (PDE), which are the proteins responsible for the production and degradation of cyclic adenosine monophosphate (cAMP), respectively. The determinant factor to decide which molecules will be activated is the level of Ca2+ concentration: high increase in Ca2+ level promotes prior activation of CaMKII, through the inhibition of PP1, and a moderated increase in the Ca2+ concentration determines the activation of PP2B and the activation of PP1. Recently, however, temporal aspects of Ca2+ stimulation have been considered an important point to determine the activity of these molecules. We constructed a computational model that contains the biochemical pathways mentioned, to study the role of different protocols of Ca2+ stimulation in the activity of these molecules. The model was constructed through ODE. The protocols used were one, two and three burst of 100 Hz, composed by 10 pulses of 1 ms, and separated by 50, 200 or 400 ms. Our results pointed that the percentage of activation of PP2B, CaMKII, PDE, and AC increased in agreement with the increases in the number of bursts utilized; in addiction, the activation of CaMKII was more effective to 50ms of interval between the bursts than 200 or 400ms. These data pointed that temporal intervals between stimulation could be a central aspect in the control of CaMKII action in the cell, mediated by different activation of PP2B, PDE, and AC.

#### Mechanisms of visual motion processing normalization in areas V1 and MT

Salva Ardid Monday Poster –M45 Wang Xiao-Jing, Albert Compte Instituto de Neurociencias de Alicante, Sant Joan d'Alacant, Spain jsardid@umh.es,xjwang@brandeis.edu

The two main areas involved in visual motion processing in the visual cortex are the primary visual area V1 and the middle temporal area MT. In V1 a third of neurons are direction-selective, but it is in area MT where the vast majority of cells encode motion aspects of the scene. Neurophysiological evidence in singleneuron experiments indicates that motion processing in each of these areas is qualitatively different. Neurons recorded in monkey's visual cortex while visually presenting random dot patterns (RDPs) in motion, reveal two different kinds of non-linear behaviour. On the one hand, there is sensory response saturation both in V1 and MT with the number of dots in the RDP, when the stimulus moves in the neuron's preferred direction. On the other hand, when two RDPs move in different directions transparently in the neuron's receptive field (RF), V1 and MT neurons respond differently. V1 neurons respond to an RDP moving in their preferred direction equally, whether or not an RDP of antipreferred direction of motion is simultaneously presented in the RF. However, MT neurons are sensitive to this dual stimulation in that a superimposed null direction stimulus suppresses the response to the preferred motion direction. Here we study, using a spiking-neuron computational model of a cortical module, what mechanisms underlie motion processing in these areas, and more especifically how these non-linear aspects of sensory responses are differentially generated in each cortical area. We find that our networks can generate the responses to direction of motion observed in areas V1 and MT. In doing so, we find that V1 makes a first normalization that consists in normalizing network activity to have a constant maximal firing in the population, and MT makes a second normalization that takes V1 output and generates responses which normalize the mean activity of the neural population. We propose one same mechanism to underlie these differential non-linear responses in areas V1 and MT. This mechanism would be based in a combination of feedforward inhibition, providing the main source of inhibition into excitatory cells; and inhibition recruited recurrently from excitatory cell activity, which is weaker and helps counteracting oversaturation.

# Neural mechanisms of the feature-similarity gain principle for attentional processing

Salva Ardid	Sunday PM Oral
Wang Xiao-Jing, Albert Compte	

Instituto de Neurociencias de Alicante, Sant Joan d'Alacant, Spain jsardid@umh.es,xjwang@brandeis.edu

Selective visual attention is known to affect neural activity in extrastriate visual areas by selectively increasing the gain of neuronal responses [1] and by biasing competition between stimuli representations [2]. In addition, recent experiments show that attention enhances the selectivity of population activity [3]. The integration of all this evidence in a single conceptual framework remains elusive, and little is known about the precise neurophysiological mechanisms involved. Here, we show through a biophysical computational model of two reciprocally connected brain areas how all this phenomenology can be accounted for by a top-down input from a working memory area that stores items in persistent activity. We find that this simple disposition is an explicit biophysical implementation of the conceptually-defined feature-similarity gain principle proposed in the literature [4]. 1. McAdams, Maunsell, J. Neurosci. 19, 431 (1999) 2. Desimone, Duncan, Annu. Rev. Neurosci. 18, 193 (1995) 3. Martinez-Trujillo, Treue, Curr Biol 14, 744 (2004) 4. Treue, Martinez Trujillo, Nature 399, 575 (1999)

#### What Defines Balanced Synaptic Input?

Monday Poster – M2

Asli Ayaz, Frances Chance

University of California Irvine, California, USA aayaz@uci.edu frances.chance@uci.edu

Cortical neurons continuously receive tremendous amounts of excitatory and inhibitory synaptic input, even in the absence of external stimuli. These synaptic inputs are thought to exist in a ibalancedî configuration, in which the majority of synaptic excitation is ibalancedî by synaptic inhibition. One hypothesis is that balanced synaptic input comprises a inoiseî signal that determines the variance of the input current to a neuron. Because the mean (time-averaged) excitation can cancel the mean inhibition, appropriately balancing synaptic input will isolate effects of noise arising from random arrivals of synaptic events. How should excitation and inhibition be balanced to achieve this effect of isolating noise? We have found that constant inhibitory and excitatory conductances can be balanced in such a way that their activation does not affect the firing-rate curve of conductance-based model neurons. The value of Ebalanced for which this effect occurs is depolarized above resting potential and is model-dependent. Our results suggest that if synaptic inputs are balanced at this potential, the effects of noise will be isolated from the additive and subtractive effects that occur because of imbalances between excitation and inhibition. We believe that is the appropriate criteria for defining balanced input.

# GABAergic excitation in striatal projection neurons: simulations and experiments

Martin Ayling Monday AM Oral Stefano Panzeri, Bracci Enrico University of Manchester, Manchester, UK <u>martin ayling@postgrad.manchester.ac.uk</u>, s.panzeri@manchester.ac.uk

It has been suggested that one of the main functions of the striatum, the primary input nucleus of the basal ganglia, is to detect and classify cortical representations of sensory events to trigger appropriate motor responses. A widely accepted hypothesis is that this function is accomplished by a "winnertakes-all" network dynamic mediated by GABAergic interactions between striatal medium spiny projection neurons. However, it is possible that, under some conditions GABAergic inputs may exert an excitatory rather than inhibitory effect. To determine whether GABAergic inputs to striatal neurons are inhibitory or excitatory, we performed a combination of simulations and experiments. Experimentally, the ability of synaptically released GABA to facilitate action potential generation in striatal projection neurons was investigated in brain slices using current-clamp, gramicidin-perforated wholecell recordings. GABAergic postsynaptic potentials (PSPs) were evoked with electrical stimuli delivered intrastriatally, and pharmacologically isolated with ionotropic glutamate receptor antagonists. Subthreshold depolarizing current injections were paired with GABAergic PSPs at different intervals. GABAergic PSPs were able to convert current injection-induced depolarisations from subthreshold to suprathreshold, but only when they preceded the current injection by an appropriate interval; accordingly, action potentials were observed 4-140ms after the onset of the GABAergic PSP, and their likelihood was maximal after 50-60ms. The GABAergic excitatory effects were fully blocked by the GABAA receptor antagonist bicuculline, and were associated with a faster rate of depolarisation during the subsequent current injection, which caused an apparent decrease in the action potential threshold level. In addition to these experiments, realistic numerical simulations were used to explore the possible facilitatory actions of GABA on glutamatergic excitatory postsynaptic potentials (EPSPs). These simulations showed that the excitatory GABAergic effects were even more robust when an EPSP, rather than a current injection, was used to depolarise the projection neuron to a similar subthreshold level. We conclude that GABAergic PSPs can exert excitatory effects on projection neurons, and this ability crucially depends on the timing between the GABAergic event and a concomitant depolarizing input. This finding has potentially radical implications for computational theories of striatal function, and suggests that, under appropriate conditions, striatal neurons may cooperate to perform computations of complexity extending beyond a "winner-takes-all" classification of cortical inputs.

# Measuring the instantaneous I-V curve for subthreshold and spike initiation voltages

Laurent Badel Sandrine Lefort Carl Petersen Wulfram Gerstner Magnus Richardson Monday Poster – M3

Laboratory of Computational Neuroscience, Lausanne, Switzerland

laurent.badel@epfl.ch sandrine.lefort@epfl.ch

The activity of many neurons in vivo is characterised by large membrane potential fluctuations. The resulting voltage distribution overlaps subthreshold regions in which many voltage-gated currents are activated. Classical I-V curves, which are measured in the absence of such fluctuations, are therefore likely to provide a distorted picture of the response properties of a neuron. Here, we present a novel method that allows for the measurement of the instantaneous current-voltage relationship of a neuron during large voltage fluctuations. The method captures the subthreshold range as well as the region of spike initiation which are both crucial for the accurate classification of the input-output properties of neurons. The validity of the method is demonstrated experimentally.

Adaptation induced suppression & facilitation: Effect of intra & extra Investigation of Glutamate and Dopamine Signaling Pathways involved in cellular ionic disturbances **Reinforcement Learning** Monday Poster – M44 Ketan Bajaj Raju Bapi Monday Poster – M14 Shesharao Wanjerkhede Basabi Bhaumik Indian Institute of Technology - Delhi, New Delhi, India ketanbajaj@ee.iitd.ernet.in ,bhaumik@ee.iitd.ac.in University of Hyderabad, Department of Computer and Info Sciences Hyderabad, India Adaptation to drifting oriented gratings has been shown to cause a shift in the orientation tuning curves of V1 cells with suppression on the flank of the tuning bapics@uohyd.ernet.in curve near the adapting orientation and facilitation on the opposite flank. To swkhede@sancharnet.in study adaptation induced responses we have developed a V1 population model having isotropic intra-cortical synaptic connections, incorporating sub-cellular Well-timed release of dopamine at the striatum seems to be important for and intrinsic membrane mechanisms and dependencies of the mechanisms on reinforcement learning mediated by the basal ganglia. Houk et al (1995) intra and extra cellular ionic concentrations. The model captures the finer details proposed a cellular signaling pathway model to characterize the interaction of recently reported experimental results on orientation plasticity. The model between dopamine and glutamate pathways that have a role in reinforcement shows that pinwheels centers are foci of orientation plasticity and there is lesser learning. We undertook the verification of the mechanisms by simulating the chemical signaling pathways in GENESIS / KINETIKIT simulator. Our orientation plasticity within iso-orientation columns. We report here for the first time that in nearby cells at pinwheel centers adaptation induced intra and extra simulation results point out that there is prolongation as well as enhancement in cellular ionic disturbances simultaneously induce suppression and facilitation. the autophosphorylated form of CaMKII (which is involved in learning and The model captures the tilt aftereffect. The model further explains how memory) as proposed by Houk et al (1995). We also found that the orthogonal adaptation can lead to sharpening and nearby adaptation lead to autophosphorylation of CaMKII occurs after a long time delay after the stimulus broadening of orientation tuning curves, which has implications for orientation onset. This is possibly due to the affinity between the autophosphorylated discrimination. Sub-cellular mechanisms in the model, replicating mitochondrial CaMKII and the NR2B, an NMDA receptor sub unit. In the absence of this calcium dynamics, explain why recovery is slower than adaptation. The model affinity, autophosphorylation of CaMKII occurs much early i.e., within a few stresses on the opinion that though synaptic mechanisms explain a number of seconds from the stimulus onset. However, our preliminary simulation results rapid neurophysiological phenomena, to explain the slower adaptation affects it fail to account for realistic time intervals involved in the dopamine activity at is important to consider the sub-cellular and membrane mechanisms which play the striatum. It is possible that AMPA and metabotropic glutamate receptor a role in cellular responses. Keywords: visual cortex, adaptation, orientation activities need to be considered in our future modifications to account for plasticity, tilt aftereffect, calcium, mitochondria biologically realistic time intervals involved in reinforcement learning. Auditory system time series analysis for both global pitch perception and harmonic segregation Subthreshold oscillations and neuronal input-output relationship Monday Poster – M70 Fabiano Baroni Emili Balaguer-Ballester Monday Poster – M9 Susan Denham Pablo Varona Center for Theoretical and Comp. Neuroscience University of Plymouth, Plymouth, UK Universidad Autonoma de Madrid, Madrid, Spain emili.balaguer-ballester@plymouth.ac.uk, sdenham@plymouth.ac.uk fabiano.baroni@uam.es The pitch heard from a complex tone is called the ifundamentali pitch and does pablo.varona@uam.es not necessarily correspond to an existing harmonic in the complex. But recent findings have shown that some spectral components of the complex can be heard The difference between resonator and integrator neurons relies upon a frequency out as a single pitch different to the fundamental, when the frequency preference for the formers, while the latters monotonically decrease their spiking relationships of the harmonics are distorted. Those experiments suggest that the probability with the frequency of a periodic input. In model neurons where auditory system follows different mechanisms for global pitch computation and dynamics on multiple time scales are present (hence ubiquitously in real for perceptual fusion of spectral components. These results constitute a neurons) the concept of frequency preference can naturally be broaden to take into account preference towards temporally specific n-uples of presynaptic challenge for current pitch perception models, which are not able to account for both the segregated component and the fundamental pitch. To overcome these inputs. On the other hand, neurons with dynamics on multiple time scale can drawbacks Roberts and Brunstrom hypothesized a qualitative explaining: global detect specific temporal patterns as we discuss in this paper. pitch perception is based on cross-channel aggregation of periodicities, but perceptual segregation of some spectral components relies on a comparison between periodicities found within the different channels. Following this idea, A model for electric field modulation of propagating neuronal activity we have been developed a new method to account for the segregation of spectral components and for the global pitch perception simultaneously. This method is Ernest Barreto Sunday Poster - S71 local in both frequency and temporal dimensions, as neurobiological data Clayton Fan, Paul So, Steven Schiff suggest, and comprises two stages: 1) an initial mechanism that detects rough differences across frequency channels using cochlea outputs and 2) a more George Mason University, Fairfax, Virginia, USA detailed dynamical periodicity extraction throughout the time-course of the ebarreto@gmu.edu,cfan@benning.net stimulus, with outputs grouped separately for the range of channels determined in previous stage. The first mechanism characterizes the time series of each Motivated by the experimental observation that electric fields modulate both frequency channel in the peripheral auditory system by a single nonlinear activity propagation and seizures, we examined the effect of an imposed electric parameter, the correlation dimension of their attractor. Comparing the values of field on spike propagation within a network of model neurons. Pinsky-Rinzel this parameter across adjacent channels gives rise to a channel grouping neurons were arranged linearly and were synaptically coupled in a nearestcriterion. This could be a rough mechanism to perceptually fuse the channels neighbor manner. Ephaptic interactions were enabled by embedding the chain in before computing pitch. The second mechanism looks at peripheral outputs in a resistive grid that modeled the electrical properties of an extracellular medium. more detail, and computes the pitches separately in each channel range. Our To model the effect of an externally applied electric field, a potential difference results indicated that the pitch extracted in one of the channel range is was applied across the grid. Transient spiking activity was elicited at one end of exclusively the frequency of the segregated component, while the rest of the the chain by a brief current pulse; this activity then propagated along the chain. ranges of channels accounts for the global pitch. Moreover, using our dynamical We found that long-range propagation of activity is possible with an imposed suppressive electric field, and that the field can modulate the speed of

pitch model, we predicted that the pitch of the segregated component does not only appears in a restricted frequency band, but also only during the first 56 ms of the stimulus, consistently with recent EEG experiments. To our best knowledge, this is the first method to provide a quantitative prediction of both global pitch and the segregated component frequency. suppressive electric field, and that the field can modulate the speed of propagation. A sufficiently suppressive field can either cause limited (i.e., finitedistance) propagation or can block propagation altogether. We clarify the role of ephaptic interactions and offer a dynamical analysis of the underlying mechanisms.

Dopamine modulates slow frequency oscillations and coherence in a prefrontal cortex network model	Genesis and synchronization properties of fast (beta-gamma range) network oscillations
Ullrich Bartsch <i>Tuesday Poster – T32</i> Daniel Durstewitz	Maxim Bazhenov Tuesday PM Oral Nikolai Rulkov
Centre for Comput. & Theo. Neuroscience, University of Plymouth Plymouth, UK	Salk Institute, La Jolla, California, US <u>bazhenov@salk.edu</u> , nrulkov@ucsd.edu
<ul> <li>ullrich.bartsch@plymouth.ac.uk</li> <li>Dopamine modulates slow frequency oscillations and coherence in a prefrontal cortex network model Ullrich Bartsch &amp; Daniel Durstewitz Centre for Theoretical &amp; Computational Neuroscience, University of Plymouth, UK Dopamine (DA) is crucially involved in normal and pathological functions of the prefrontal cortex (PFC), especially working memory. During working memory, oscillatory activity in different frequency regimes has been observed, to which single neurons may phase lock. Computational models have focused so far mainly on firing rate-multistability as a mechanism for working in PFC has hardly been investigated. We studied DA modulation of network dynamics in a biophysical model of the PFC that exhibits chaotic spontaneous activity with slow frequency oscillations (&lt; 1Hz)</li> <li>Short-Term Plasticity in a Computational Model of the Tail-Withdrawal Circuit in Aplysia</li> <li>Douglas Baxter Tuesday Poster – T49 John Byrne</li> <li>Department of Neurobiology and Anatomy, Houston, Texas, USA</li> </ul>	Fast network oscillations in beta-gamma range are associated with attentiveness and sensory perception and have strong relation to both cognitive processing and temporal binding of sensory stimuli. These oscillations are found in different brain systems including cerebral cortex, hippocampus and olfactory bulb. Cortical gamma oscillations may become synchronized within 1-2 msec over distances up to a few millimeters and have been shown to be critical for feature integration in perception and may control the occurrence and polarity of Hebbian modifications. Despite the importance of these processes, genesis and synchronization mechanisms of fast beta (15-30 Hz) and gamma (30-80 Hz) activities remain poorly understood. In this study we used computational network models to analyze basic synaptic mechanisms and properties of fast network oscillations. Neuronal behavior was simulated using map-based models implemented with difference equations (maps). Using the network models of synaptically coupled regular-spiking pyramidal neurons (up to 420,000 cells) and fast spiking interneurons (up to 105,000 cells) we found that the strength of inhibitory inputs from interneurons to pyramidal cells was critical to set the properties of the ensemble oscillations. Changing the strength of inhibitory feedback controlled transitions between persistent and transient forms of gamma oscillations. Long-range excitatory connections between pyramidal cells were not required for global synchrony of network oscillations. Strength of synaptic interactions between pyramidal cells and interneurons defined the synchronization state: either global network synchronization with near zero phase lag between remote sites or local synchrony mediated by waves of gamma
<u>douglas.baxter@uth.tmc.edu</u> , john.h.byrne@uth.tmc.edu	activity propagating through the network.
Previously, a computational model was used to assess the relative contributions of mono- and polysynaptic pathways to the tail-withdrawal reflex of Aplysia (White et al. 1993). The results suggested that the monosynaptic pathway from sensory neurons to motor neurons could not account for the empirical	Motion Aftereffects in a Self-Organizing Model of the Primary Visual Cortex
sensory neurons to motor neurons could not account for the empirical observation that brief stimuli to the tail elicit long-duration responses in motor neurons (Walters et al. 1983). Rather, the polysynaptic pathway from sensory	James Bednar Tuesday Poster – T94 Christopher Ball
neurons to interneurons (Pl17s) to motor neurons primarily determined the duration of a response and converted an amplitude-encoded input into an amplitude- and duration-encoded output. Although a helpful heuristic, the model failed to incorporate several key biophysical properties of the sensory neurons,	The University of Edinburgh, School of Informatics, Edinburgh, UK jbednar@inf.ed.ac.uk, ceball@gmail.com
such as homosynaptic plasticity. The goal of the present study was to extend the model and to investigate the ways in which homosynaptic plasticity contributes to information processing in the tail-withdrawal neural circuit. The model was extended by including short-term, homosynaptic depression and potentiation into the connections of sensory neurons with their follower cells. The time courses of depression and potentiation were a few seconds, with potentiation being the slower of two. In addition, a range of input stimuli were examined, including brief (1 sec), constant frequency (3 to 19 Hz) stimuli and stimuli that mimic physiological responses of sensory neurons to the electrical stimuli used to elicit tail-withdrawal reflexes in vivo. Spike activity in the sensory and motor neurons were the input and output of the circuit, respectively. Homosynaptic depression limited the amount of motor neuron activity that could be elicited by stimulating the monosynaptic pathway alone (Phares et al. 2003). Potentiation within the monosynaptic pathway. This synergism extended the dynamic range of the input-output relationship of the network. In addition, the balance between depression and potentiation made the circuit respected the dynamic range of	The LISSOM (Laterally Interconnected Synergetically Self-Organizing Map) model has previously been used to simulate the development of primary visual cortex (V1) maps for orientation and motion processing. In this work, we show that the same self-organizing processes driving the long-term development of the map result in illusory motion over short time scales in the adult. After adaptation to a moving stimulus, the model exhibits both motion aftereffects (illusory motion for a static test pattern, also known as the waterfall illusion or MAE) and the direction aftereffect (systematic changes in direction perception for moving test patterns, the DAE). Together with previous results replicating the tilt afferefect (TAE) for stationary patterns, these results suggest that a relatively simple computational process underlies common orientation and motion aftereffects. The model predicts that such effects are caused by adaptation of lateral connections between neurons selective for motion direction and orientation.

depression and potentiation made the circuit responded preferentially to longduration, low frequency inputs. For example, an input of 5 spikes at 20 Hz elicited a 2.2 s burst of 11 spikes in the motor neuron. In contrast, an input of 5 spikes at 5 Hz elicited a 3 s burst of 16 spikes. Due to its faster kinetics, depression reduced circuit efficacy during brief, high-frequency stimuli. As the stimulus duration was increased, however, the more slowly developing potentiation restored circuit efficacy. Supported by NIH grant R01 RR11626.

Storing sparse random patterns with cascade synapses	A biophysical model to explore the effects of network activity on short-term synaptic depression	
Daniel Ben Dayan-Rubin Sunday Poster – S92		
Stefano Fusi	Jose Manuel Benita Monday Poster – M40	
	Antoni Guillamon	
INI-institute of neuroinformatics, Zurich, Switzerland	Gustavo Deco	
	Maria V. Sanchez-Vives	
dbd@ini.phys.ethz.ch, fusi@ini.unizh.ch		
	Universidad Politecnica de Catalunya, Barcelona, Spain	
New experiences can be memorized by modifying the synaptic efficacies. Old		
memories are partially overwritten and hence forgotten when new memories are	jose.manuel.benita@upc.edu	
stored. The forgetting rate depends on the number of synapses which are	antoni.guillamon@upc.edu	
modified: networks in which many synapses are highly plastic and hence change		
following each experience, are good at storing new memories but bad at	Short-term synaptic depression (STD) is a process that modifies the probability	
retaining old ones. On the contrary a small number of synaptic changes (rigid	of transmitter release. Recent experiments show that the reduction of STD over	
synapses) means good memory retention, but poor performance at storing new	time is related to the intensity of spontaneous rhythmic activity. In order to study	1
memories. Recently Fusi, Drew and Abbott (2005), introduced a model of a	the effect that network activity has on STD, we built a biophysical network	
synapse which has a cascade of states, each characterized by a different degree	model and measure STD in it (from EPSPis amplitude of hyperpolarized	
of plasticity. Each stimulus can modify the synaptic efficacy or induce a	neurons) in two different stages that mimic iclassicali artificial cerebrospinal	
transition to a different state (metaplasticity). Such a synapse combines the	fluid (ACSF) and imodifiedî ACSF, according to the experimental results. Our	
advantages of plastic synapses with those of more rigid synapses, outperforming	results show that slow oscillations generated by the changes in the potassium	
the models in which each synapse is characterized by a single predefined degree	concentration can account for the STD reduction, but we also explore other	
of plasticity. In that work the authors assumed that each synapse was modified independently. Moreover, they estimated the memory capacity by measuring the	factors that could explain this reduction.	
correlation between the synaptic configuration right after a particular experience		
was stored, i.e. when the memory was still vivid, and the synaptic configuration	Models of Correlated Poisson Processes: Rate Covariance and Spike	
obtained after the synapses were exposed to a certain number of new	Coordination	
experiences. The problem of how this information is actually retrieved in a	Coordination	
dynamic network of neurons was ignored. Here we consider a two layer network	Staude Benjamin Tuesday Poster –T15	
in which input neurons are connected to output neurons through cascade	Stefan Rotter	
synapses. In our case and in the case of every network, different synapses turn	Sonja Gruen	
out to be <i>correlated</i> even when storing random and uncorrelated input and the	Sonju Oravn	
output patterns. We analyze how the memory performance depends on the	Neuroinformatics, Freie Univiersity Berlin	
statistics (sparseness) of the patterns to be memorized. Given that the sparseness	Bernstein Center Computational Neuroscience, Berlin, Germany	
of the pattern can significantly reduce the number of synapses which are needed	1 , , , ,	
to be modified to store new memories, is it still advantageous to have a cascade	staude@neurobiologie.fu-berlin.de	
synapse with metaplasticity? We show that cascade synapses have always a	rotter@biologie.uni-freiburg.de	
better memory performance.		
	This study explores the statistical properties of correlated Poisson processes as	
	models of the spiking activity of neurons recorded in parallel. As a new model,	
	we introduce the `covarying rate process' (CRP) that produces correlation due to	
Coding Communication Signals with Synchrony and Asynchrony	jointly varying firing rates. This model will be compared to a `jittered	
	coincidence process' (JCP) (Gruen et al, 1999; Kuhn et al, 2003) that features	
Jan Benda Sunday AM Oral	temporally coordinated spiking activity with stationary firing rates. For both	
Andre Longtin, Len Maler	models, we provide explicit mathematical expressions that relate the model	
	parameters to the mean firing rate, count correlation coefficient and temporal	
ITB, Humboldt University, Berlin, Germany	scale of correlation. This yields two models with identical biologically relevant	

j.benda@biologie.hu-berlin.de,alongtin@physics.uottawa.ca

Synchronous spiking of neural populations is hypothesized to play important computational roles, like for example in solving the binding problem, attention, and cortical communication. We present an example where the opposite, i.e. the desynchronization of a neural population encodes a transient communication signal. During male-female interaction of weakly electric fish the superposition of the electric fields results in an ongoing high frequency beat of about 100 to 300 Hz. Our in vivo recordings of P-unit electroreceptor afferents in Apteronotus lepthorhynchus (single unit, dual unit, and whole nerve recordings) clearly show a highly synchronous response to such beats. However, whenever a male emits a courtship signal, a so-called type-I or large chirp, the beat is interrupted for about 25 ms and the response of the electroreceptor population becomes desynchronized. The mean firing rate during the synchronous and asynchronous response is approximately the same. We conclude that desynchronization of the spike response can be as important as synchronous spikes. The situation is completely reversed during a male≠male encounter where beat frequencies are lower than about 50 Hz and a different type of chirps, so called type-II or small chirps, are emitted as an aggression signal. Such slow beats simply modulate the firing rate of the electroreceptors; the spike times of different electrorecptors are uncorrelated. A small chirp generates a sudden increase or decrease of the electric field amplitude that transiently boosts or reduces the electroreceptor's firing rate and thus causes a brief period of increased synchrony. In summary, depending on the social context, the spike response of the population of electroreceptor is either synchronized or desynchronized by a communication signal. This example clearly demonstrates that in general it is the change of the degree of synchrony that codes a signal and not synchrony as such.

This study explores the statistical properties of correlated Poisson processes as models of the spiking activity of neurons recorded in parallel. As a new model, we introduce the 'covarying rate process' (CRP) that produces correlation due to jointly varying firing rates. This model will be compared to a 'jittered coincidence process' (JCP) (Gruen et al, 1999; Kuhn et al, 2003) that features temporally coordinated spiking activity with stationary firing rates. For both models, we provide explicit mathematical expressions that relate the model parameters to the mean firing rate, count correlation coefficient and temporal scale of correlation. This yields two models with identical biologically relevant parameters, whereas the mechanisms producing the correlation differ. Sample data generated by the two models are analyzed using cross-correlation techniques. The time scale of the correlation cannot be reveiled. Cross-correlations from data of both models look identical, even for a variety of predictors. The usage of the 'correct' predictor implies knowledge of the underlying process and has to be chosen accordingly. Only then data originating from the two types of model can be differentiated. We will discuss further analyses that, if applied additionally, help to obtain better knowledge about the underlying process. Acknowledgments. Funded by NaFoeG Berlin, the German Ministry for Education and Research (BMBF grants 01GQ01413 and 01GQ0420), and the Stifterverband fuer die Deutsche Wissenschaft. Support by the IGPP Freiburg is gratefully acknowledged.
Modeling L-LTP by means of changes in concentration of CREB Spatially organized spike correlation in cat visual cortex transcription factor		cortex	
•		Denise Berger	Monday Poster –M56
Lubica Benuskova	Tuesday Poster – T77	David Warren	
Nikola Kasabov		Richard Normann	
		Sonja Gruen	
KEDRI, Auckland University of Technology, Auckl	and, New Zealand		
		Neuroinformatics, Free Univiersity Berlin, Berlin, Ge	ermany
lbenusko@aut.ac.nz			
nkasabov@aut.ac.nz		d berger@gmx.net	
-		david.warren@ieee.org	

In this study we simulate the induction of decremental (early) and nondecremental (late) long-term potentiation (E-LTP and L-LTP, respectively) in the hippocampal dentate gyrus by means of a new synaptic plasticity rule. A new synaptic plasticity rule is the result of combination of the spike-timingdependent plasticity (STDP) and the moving LTD/LTP threshold from the Bienenstock, Cooper and Munro (BCM) theory of synaptic plasticity. Another novelty in the synaptic plasticity rule is that the activity-dependent equation for the moving LTD/LTP threshold is comprised of two temporal processes: a fastand a slow-activity integration process. The fast activity-integration relation depends on average postsynaptic spike count over the recent past calculated as in [1]. The slow temporal relation for LTD/LTP threshold is related to the changes in concentration of phosphorylated CREB (cAMP-responsive element binding) transcription factor as measured in [2]. Our computational model faithfully reproduces results of experimental study both with respect to E-LTP and L-LTP [2]. The key to the successful simulation of L-LTP is the temporal evolution of phosphorylation of CREB, which is the major transcription factor involved in learning and memory known today that links synaptic stimulation with gene expression. In our computational model, we incorporated the temporal changes in the levels of pCREB into the dynamics of the BCM synaptic modification LTD/LTP threshold that determines the magnitude of synaptic potentiation and depression in STDP, which is our novel and original contribution. Our work can be considered to be the first step in the computational neurogenetic modelling of learning and memory. References [1] Benuskova, L., Rema, V., Armstrong-James, M. and Ebner, F.F. (2001) Proc. Natl. Acad. Sci. USA 98, 2797-2802. [2] Schulz, S., Siemer, H., Krug, M. and Hollt, V. (1999) J. Neurosci. 19, 5683-5692.

#### Properties of the cerebellar Golgi cell and implications for network behaviour

Michiel Berends Quinten Robberechts Erik De Schutter

Tuesday Poster -T16

Theoretical Neurobiology, Univ. Antwerp, Antwerp, Belgium

michiel@tnb.ua.ac.be quinten@tnb.ua.ac.be

The information flow from mossy fibers to Purkinje cells in the cerebellum is controlled for a large part by the Golgi cells. We constructed a minimal conductace-based model of the Golgi cell, mimicking well experimental findings. Golgi cells show autorhytmicity and spike-frequency adaptation. The consequences of these properties for the single-cell input-output characteristics are investigated. Furthermore the roles of autorhythmicity and adaptation in a network of coupled granule cells and Golgi cells are explored.

Inspired by optical recordings from visual cortex which show maps of orientation selectivity, we approach the question of how the concept of cortical maps may be related to the concept of temporal coding. More specifically we ask, whether neurons within areas that are typically assigned to the same orientation tuning also preferably exhibit spike correlation. To this end we analyze parallel spike recordings performed using a 10 x 10 electrode grid covering an area of 3.6 mm x 3.6 mm of cat visual cortex (Warren et al., 2001) for occurrence of spike correlation. These recordings allow us to address the question of the relation of correlated neuronal activity to distance and spatial arrangement of the recording sites. We extracted multi-unit activity (MUA) and calculated the pairwise correlation by cross-correlation between all possible MUA pairs. We considered a pair to be correlated if the raw cross-correlation significantly exceeded the predictor derived by boot-strap methods. Then we examined the distances between the electrodes from which correlated MUAs were recorded from. By doing this we retrieve a probability distribution of finding a correlated pair as a function of distance. This distribution appears to be bimodal with maxima at distances lower than 1 mm and about 3.5 mm. In addition, we evaluated the spatial arrangement of the correlated pairs and found that MUAs that are involved in a correlated pair are not equally and randomly distributed across electrodes, but cluster in space. Setting a threshold of a minimum of two of being involved in correlated MUA pairs leads to a separation into 3-4 (depending on the stimulus condition) separate subgroups that exhibit multiple pairwise correlations. Most of the MUAs are typically involved in many (up to 15) pairwise correlations. The spatial scales in this correlation map are in agreement with the scales for orientation tuning maps found by optical imaging (Hubener et al., 1997) and by electrophysiological recordings (Warren et al., 2004) suggesting that locally arranged neurons of the same tuning may also express correlated activity. Acknowledgments: Partial funding by the German Ministry for Education and Research (BMBF), the Stifterverband fuer die Deutsche Wissenschaft, and the Volkswagen Foundation.

#### Switching between gamma and theta: dynamic network control using subthreshold electric fields.

Julia Berzhanskaya Anatoli Gorchetchnikov Steven Schiff

TuesdayPM Oral

Krasnow Institute, Fairfax, Virginia, USA

jberzhan@gmu.edu, anatoli@cns.bu.edu

Oscillatory rhythms are thought to play a significant role in hippocampal cognitive functions. A definite test of causative relationships, however, is complicated by a nonspecific nature of pharmacological and/or electric manipulations used to modify or eliminate these rhythms. An adaptive subthreshold electric field modulation technique (Gluckman et al., 01) represents a flexible and powerful alternative. Unlike traditional stimulation protocols it uses weak continuous electric fields to interact with network dynamics. While effects of such fields at the single cell level have been studied, the effect at the population level might be hard to predict. Here we use a computational model to test an effect of an electric field modulation on network activity. Our two-dimensional spiking model of hippocampus includes pyramidal and OLM neurons as well as basket cells, based on the recent work by Gloveli et al., 05 and Kunec et al., 03. Electric field effects on individual neurons are estimated from both experimental data (Bikson et al., 04, Berzhanskaya et al., 05) and morphologically detailed modeling. We show that a simple manipulation by a local subthreshold field is sufficient to switch between theta, gamma and theta/gamma regimes of hippocampal activity and discuss possible experimental implications.

An electrode's eye view of the rat olfactory bulb:	using recordings and	Stability of Spike Timing Dependent Plasticity	Tuesday AM Oral
modeling to make a map		Guy Billings, Mark van Rossum	
Upinder Bhalla	Monday Poster – M80		
Rinaldo D'Souza		The University of Edinburgh, Edinburgh, UK	
Kalyanasundaram Parthasarathy		g.o.billings@sms.ed.ac.uk,	
, , , , , , , , , , , , , , , , , , ,		mvanross@inf.ed.ac.uk	
NCBS, Bangalore, India			
		We compared the stability of weight dependent Spike	e Timing Dependent
bhalla@ncbs.res.in,		Plasticity (wSTDP) and non weight dependent STDP	0 1

An electrodeís eye view of the rat olfactory bulb: using recordings and modeling to make a map. R. DíSouza, K. Parthasarathy, U.S. Bhalla\* NCBS, Bangalore Spatial activity maps have been very informative about glomerular-level organization of olfactory bulb activity, and constitute a useful map of olfactory bulb inputs. It is desirable to obtain correspondingly high spatial and temporal resolution maps from the mitral cells of the olfactory bulb, as output maps. Here we report a method to combine models and multiunit recording to construct a high temporal-resolution activity map of mitral-cell layer of the olfactory bulb. Multi and single-unit recording from the bulb are complicated by high background activity, and we sought to characterize contributions to this background. In particular, the active secondary dendrites of mitral cells might lead to significant contributions to multiunit recording from cells several hundred microns away from the recording site. We used 283-compartment models of mitral cells and positioned them over an ovoid representation of the olfactory bulb. We calibrated a current-to-firing interval curve and used this to drive each cell using glomerular current injection. We simulated 120 cells in each run. Each cell was driven to replicate recorded single-unit firing activity from different bulbar neurons. Using line-source field calculations we summed current contributions over all model compartments into an array of recording sites. We ran simulations with cells packed at physiological density, at different distances from the recording sites. In parallel, we used multiunit recordings from an array of electrodes to map mitral-cell-layer activity in the rat olfactory bulb. The recordings were done using formvar-insulated nichrome electrodes, anesthetized rats and standard surgical and stereotaxic methods. The array was lowered in 300 micron steps, throughout the depth of the bulb. Four odorants were used as stimuli at each depth, and the odor was presented in several repetitions to improve statistical confidence. We compared recordings with simulated responses of electrodes at different depths and different distances from the simulated neurons. Recordings have greater high-frequency components, which we interpret as due to the much larger number of actual neurons than we could simulate. In preliminary analysis we predict that most of the high-amplitude spikes are due to neurons in the near vicinity of the electrode, rather than secondary dendrites of distant neurons. Thus, suitable thresholding may be a good way of narrowing down the ëfield of viewí of the electrode.

rinaldo@ncbs.res.in

Plasticity (wSTDP) and non weight dependent STDP (nSTDP). We tracked the autocorrelation of a set of STDP weights at equilibrium connected to a single integrate and fire neuron using biologically plausible parameters. We found that wSTDP has an autocorrelation that decays with a far shorter timeconstant than that of nSTDP (120s vs 19 hours). Thus, ensembles of wSTDP synapses have a tendency to decorrelate with their previous values more rapidly than do ensembles of nSTDP synapses. Consequently storage of information using synaptic weights will be unstable in the wSTDP case as compared to the nSTDP case. Next we considered the stability of receptive fields within recurrent networks of 60 integrate and fire neurons using wSTDP and nSTDP learning rules with lateral inhibition. Both wSTDP and nSTDP networks developed orientation columns when provided with spatially periodic rate modulated Poisson inputs centered at random locations. After training we tracked the autocorrelation of the population vectors corresponding to the receptive fields within the network. We found that receptive fields within wSTDP networks partially decorrelate with themselves over a timescale of around 250s whereas receptive fields in nSTDP networks do not. Although wSTDP networks are more variable around their mean selectivities than nSTDP networks, the receptive fields do not completely decorrelate with themselves over time. Hence wSTDP networks can support stable receptive fields. Finally we examined how our networks responded to a change in input statistics. After training on randomised input as before, we presented the networks with a stimulus protocol matching experimental protocols used to induce orientation selectivity shifts in cat visual cortex. The protocol consists of stimulating the network at input locations tuned to two adjacent selectivites (orientation columns in V1) in such a way as to elicit STDP between those columns. We found that upon presentation of the protocol the receptive fields reorganise themselves. In the case of nSTDP the receptive fields change from a map to a column that is selective for one of the input locations in the protocol. In the case of wSTDP the receptive fields of neurons that are not activated in the protocol decay away. However activated neurons retain their receptive fields.

#### The brain implements optimal decision making mechanisms

Rafal Bogacz Kevin Gurney Tobias Larsen Monday Poster -M66

rafal@cs.bris.ac.uk k.gurney@sheffield.ac.uk

Neurophysiological studies have identified a number of brain regions critically involved in solving the problem of ëaction selectioní or ëdecision makingí. In the case of highly practiced tasks, these regions include cortical areas hypothesized to integrate evidence supporting alternative actions, and the basal ganglia, hypothesised to act as a central switch in gating behavioural requests. However, despite our relatively detailed knowledge of basal ganglia biology and its connectivity with the cortex, and numerical simulation studies demonstrating selective function, no formal theoretical framework exists that supplies an algorithmic description of these circuits, and that can explain why they are organized in the specific way they are. This paper addresses this question by showing how many aspects of the anatomy and physiology of the circuit involving the cortex and basal ganglia are exactly those required to implement the computation defined by an asymptotically optimal statistical test for decision making in the Multiple Sequential Probability Ratio Test (MSPRT). The resulting model of basal ganglia provides a rationale for their inter-nucleus connectivity and the idiosyncratic properties of particular neuronal populations.

Self-organized 40 Hz synchronization in a physiological theory of EEG		A non-parametric electrode model for intracellular recording	
Ingo Bojak David Liley Swinburne University of Technology	Tuesday PM Oral	Romain Brette Zuzanna Piwkowska, Michelle Rudolph, Thierry Bal, A Ecole Normale SupÈrieure, INRIA, Paris, France <u>brette@di.ens.fr</u> , zuzanna.piwkowska@iaf.cnrs-gif.fr	<i>Monday Poster -M4</i> lain Destexhe
CISCP, LSS H31, Hawthorn, VIC, Australia ibojak@swin.edu.au,dliley@swin.edu.au		We present a new way to model the response of an elec current. The electrode is represented by an unknown co	
We present evidence that large-scale spatial coher emerge dynamically in a cortical mean field theory		characterized by a kernel which we determine by inject show both in simulations and experiments that, when a	ing a noisy current. We oplied to a full recording
synchronization time scale is about 150 ms, which compares well with experimental data on large-scale integration during cognitive tasks. The same model has previously provided consistent descriptions of the human EEG at rest, with tranquilizers, under anaesthesia, and during anaesthetic-induced epileptic seizures. The emergence of coherent gamma band activity is brought about by changing just one physiological parameter until cortex becomes marginally unstable for a small range of wavelengths. This suggests for future study a model of dynamic computation at the edge of cortical stability.		setup (including acquisition board and amplifier), the method captures not only the characteristics of the electrode, but also those of all the devices between the computer and the tip of the electrode, including filters and the capacitance neutralization circuit on the amplifier. Simulations show that the method allows correct predictions of the response of complex electrode models. Finally, we successfully apply the technique to challenging intracellular recording situations in which the voltage across the electrode during injection needs to be subtracted from the recording, in particular conductance injection with the dynamic clamp protocol. We show in numerical simulations and confirm with experiments that the method performs well in cases when both bridge recording and recording in	
A system-level brain model of spatial working i	nemory and its impairment	discontinuous mode (DCC) exhibit artefacts. (This wor CNRS, INRIA, European Commission (FACETS, FP6- Concertee Incitative (NIC0005).)	
Alan Bond	Sunday Poster –S100	Functional penetration of variability of motor neuro	on spike timing through
National Institute of Standards and Technology, G	aithersburg, Maryland, USA	a neuromuscular model	
alan.bond@exso.com		Vladimir Brezina	Monday Poster –M62
A system-level model of spatial working memory computer science and logical modeling approach. remembered is located in a lateral parietal area, an representation including object identities and obje driven by plans which are stored in a separate mor prefrontal and then copied to a planning module c prefrontal, where they are executed and sequenced maintained by explicit messages from a currently use a saved mental image for motor output or eye the plan causes the image to be temporarily reinsta motor control. We describe a gradual approach to attenuates, causing the plan to fall below a threshot to match the experimental results of Conklin et al schizoptypal subjects could carry out a spatial wo second delay but not when there was a 7 second delay Alla Borisyuk David Terman Brian Smith Xueying Wang Sungwoo Ahn Jeong-Sook Im	The mental image which is d is part of a larger distributed et appearances. The system is lule corresponding to ventral orresponding to dorsal . Mental images are executed plan. Upon a cue to movement, a message from ted allowing it to be used for deficits in which a goal ld. This approach allowed us in which schizophrenic and king memory task with a 0.5 elay. Monday Poster –M81	Mt. Sinai School of Medicine, New York, New York, U vladimir.brezina@mssm.edu The B15-B16/ARC neuromuscular system of Aplysia, a feeding neuromusculature, is a model system for the stu modulation and control. The ARC muscle is innervated B15 and B16, which release their classical transmitter, . muscle. In addition, however, both motor neurons relea cotransmitters that, through a network of modulatory ac shape the basal ACh-induced contractions. Recent work variability in essentially all parameters of the feeding be spike patterns of the motor neurons. What is the impact contractions of the muscle, and on the modulatory action motion by the motor neuron firing? Here we ask this qu low-level variability or irregularity in the timing of succ each motor neuron burst. We drive a model of the B15/ either the real, irregular spike patterns of the motor neu in comparison, the corresponding iregularizedî patterns intraburst variability. The regularization of the spike pa amplitude, and more surprisingly also the mean amplitu the downstream variables in the model. Thus, the variat the input to the system penetrates throughout the system release, modulator concentrations, modulatory actions, muscle. Furthermore, not only does the variability pene but it is actually instrumental in maintaining its modula robust, physiological level.	a part of the animalís idy of neuromuscular by two motor neurons, ACh, to contract the se modulatory peptide ctions in the muscle, then c has found great ehavior, including in the of this variability on the ons that are also set in testion with respect to the cessive spikes within B16-ARC system with rons recorded in vivo, or, , lacking just the tterns decreases the peak ide, of essentially all of pility of spike timing at n, affecting modulator and the contraction of the trate through the system,
borisyuk@math.utah.edu, terman@math.ohio-stat		A Model for Modulation of Synchronisation by Atte	ntion
Experiments have demonstrated that projection ne mammalis olfactory bulb or insectis antennal lobe firing patterns in response to an odor. The consist of epochs in which a subset of PNs ʂ subsequent epoch, PNs join in and drop out of the idynamic clusteringî. We present a biologically m produces dynamic clustering, as well as other com	(AL) produce complex firing patterns may 57;re synchronously. At each ensemble, giving rise to otivated model of the AL that plex features of AL activity	Andres Buehlmann Rita Almeida, Gustavo Deco Universitat Pompeu Fabra, Barcelona, Spain <u>andres.buhlmann@upf.edu</u> , ritap.almeida@upf.edu In a recent work, Fries et al. (2001) measured the in	
produces dynamic clustering, as wer as other complex relatives of AL activity patterns. For example, the model exhibits divergence of representation of similar		on the responses of monkey V4 neurons, while the anin	

In a recent work, Fries et al. (2001) measured the influence of attention on the responses of monkey V4 neurons, while the animals attended to one of two visually presented stimuli. Based on electrophysiological recordings they observed that neurons activated by the attended stimulus showed an increase in gamma-frequency synchronisation and a decrease in low-frequency synchronisation when compared to neurons activated by distractors. Here, we present a model using a network of recurrently connected integrateandfire neurons to explain the experimental results. Our model shows that the increase in coherence can evolve from the biased competition between neurons receiving inputs from an attended stimulus and a distractor stimulus.

odors over time (odor differentiation) as well as convergence of representations

of other odor classes (odor generalization). Both of these features are prominent

in the olfactory system and are learning-dependent. Using singular perturbation

methods, we reduce the analysis of the model to an algorithm based on a directed graph. The algorithm allows us to systematically study how properties

of the attractors and transients depend on parameters including the network

architecture.

A Scheme for Temporal Pattern Recognition Sunday Poster	r – <i>S94</i> Synaptogenesis and neurogenesis are rela dentate gyrus of gerbils	ated phenomena in the adult
Anthony Burkitt, Hamish Meffin, David Grayden		
The Bionic Ear Institute, East Melbourne, Australia	Markus Butz	Tuesday Poster – T85
aburkitt@bionicear.org, meffin@zi.biologie.uni-muenchen.de	Gertraud Teuchert-Noodt, Prof. Dr. Dr.	
A network structure is proposed that enables temporal pattern recognit		f Bielefeld, Bielefeld, Germany
neural systems. Temporal patterns consisting of sequences of symbols	are	
constructed and presented to the network as ordered pairs of symbols.	In its markus.butz@uni-bielefeld.de	
initial state, the network consists of ipoolsî of recurrently connected no	eurons, g.teuchert@uni-bielefeld.de	
with one such pool for each symbol. In the scheme presented there is a	in	
oscillating global inhibitory input to the network. The synaptic connect	tions We propose a biological network model to o	describe neurogenesis and
between pools of neurons are learnt using spike-timing dependent plas	ticity synaptogenesis in the hippocampal denatate	e gyrus as interdependent processes.
(STDP), in which modification of the synaptic strengths depends upor	the Simulating the synaptic reorganisation proc	ess among proliferating and pre-
precise relative timing of synaptic inputs and spike outputs. The oscill	ation of existing neurons by our network model pred	dicts an optimal synaptogenesis for a
the background inhibitory neural activity during learning plays a role s	similar to moderate cell proliferation whereas an incre	eased cell proliferation leads to a
that proposed by Mehta and colleagues (Mehta et al., 2002) for explain	ning both reduced synaptogenesis. This effect is also of	observed experimentally in the

that proposed by Mehta and colleagues (Mehta et al., 2002) for explaining both phase precession and temporal sequence learning in the hippocampus. The model proposed here extends these models of hippocampal function in a number of important aspects. First, there are a large number of possible temporal patterns, in contrast to the one-dimensional arrangement of hippocampal place fields (corresponding to a linear track or a loop track). Second, the temporal patterns in which we are interested have a discrete nature, in contrast to the (quasi-) continuously varying place fields of hippocampal neurons. Third, each symbol can be associated with a number of different possible temporal patterns and consequently the neural representation of each symbol must learn to distinguish each different temporal pattern of which it forms a part. To distinguish between multiple possible patterns, we propose a mechanism based upon symmetry breaking between synaptic subgroups with STDP (Meffin et al., 2006). The network is shown both to store and to recognize temporal sequences of symbols. The rate of presentation of the symbols in the temporal sequence is around 4 symbols/second, which is characterized as a behavioral time scale that is in contrast to the neurophysiological time scale of the order of tens of milliseconds (i.e., the time scale of the STDP time constants for potentiation and depression (Bi & Poo, 1998)). The storage and retrieval mechanism is found to be robust to wide variations in the presentation rate as well as the period of the inhibitory oscillation. Another measure of the performance of the recognition ability of the network is its primingîability, namely the increased activity of subpools of neurons that are associated with allowed future symbols in a temporal sequence.

### Contrast adaptation in descriptions of visual neurons that incorporate spike-history dependence

Sunday Poster – S19 Daniel Butts, Liam Paninski Division of Engineering and Applied Science, Harvard University, Cambridge, Massachusetts, USA dbutts@deas.harvard.edu, liam@stat.columbia.edu

Changes in the response properties of visual neurons to the overall contrast of the visual scene allow neurons to function in the wide range of conditions present in the natural environments. While responses of neurons in the retina and lateral geniculate nucleus (LGN) are well-described by a linear receptive field, contrast adaptation is not explained by traditional receptive-field based models, leading to more complex models that incorporate contrast adaptation through additional mechanisms such as contrast gain control. Neurons in the retina and LGN respond to dynamic visual stimuli with temporal precision on the order of milliseconds, which is also not captured by standard linear models of these neurons. As a result, much recent work has explored how incorporating spike-history effects (such as refractory effects) can account for the temporal precision of these neurons. Here, we demonstrate that models with spike-history dependence (that can explain the temporal precision of these neurons) also demonstrates non-trivial contrast adaptation, meaning that their input-output relationship changes with contrast. Certain aspects of contrast adaptation observed in real neurons, such as contrast gain control and the presence of a suppressive surround are in fact features of these neuronal models, which result from spike-history dependence alone. To untangle non-trivial effects of contrast adaptation from the rather straightforward non-linearities associated with neuronal spike generation, we apply the framework developed by Paninski (2004) to fit a receptive-field based model with spike-history dependence to arbitrary visual data with high temporal precision. Such a model can be applied to both spatiotemporal white (uncorrelated) noise and natural movies, while capturing the temporal precision of real neuron responses. We thus explore how the resulting description of visual neuron function can simultaneously capture many non-linear elements of the neuronal response, and provide a simple yet general description of neuronal function that can be easily extracted from neuronal data.

#### **Recruitment of Presynaptic Vesicles and Facilitation of Transmitter** Release

dentate gyrus of gerbils: Impoverished in contrast to semi-naturally reared

adulthood. Our recent quantitative immun-histochemical data now proof a

animals are known to have a permanently increased dentate cell proliferation in

significantly reduced synaptogenesis ñ quantified by the densitiy of lysosomal

processes in the DG. Furthermore, impoverished reared gerbils treated with a

single juvenile methamphetamine intoxication have an adult cell proliferation

rate again lowered to normal levels. In accordance with the theoretical

predictions, as we could also show, these animals have a less decreased

synaptogenesis than the non-treated impoverished reared group. Thus, the

experimental data strongly support the theoretical explanation model for the

synaptic integration and survival of new neurons, in particular, in the dentate

Maria Bykhovskaia

gyrus of the rodent brain.

Monday Poster -M30

Lehigh University, Bethlehem, Pennsylvania, USA

#### mabv@lehigh.edu

Facilitation is a process in which synaptic transmission is enhanced by repetitive stimulation. Facilitation is due to an increase in the number of vesicles released by an action potential. To understand how presynaptic machinery governs facilitation we performed Monte Carlo simulation of presynaptic vesicle priming and release. The model was validated by comparison of simulation outputs with experimental measurements of facilitation at the lobster neuromuscular junction, a model system that demonstrates extremely pronounced and robust facilitation. The main features of the model are the plasticity of the readily releasable pool of presynaptic vesicles and Ca2+ dependent vesicle priming. The model incorporates: 1) slowly releasable pool of vesicles (SRP), 2) readily releasable pool (RRP) and 3) released vesicles or neurosecretory quanta. Each cycle of the Monte-Carlo simulation corresponds to the response of a presynaptic terminal to a single action potential. The number of vesicles released in response to each action potential in synchronous and asynchronous modes, the release timecourse, and the sizes of the SRP and the RRP were monitored. To test and validate the model, we used experimental measurements of the release timecourse, facilitation, and the increase in the releasable pool produced by persistent nerve stimulation at the lobster neuromuscular synapse. Two facilitation forms were investigated: 1) igrowthî facilitation, the rate of increase in the transmitter release as the nerve is stimulated repetitively, and 2) iplateauî facilitation, the increase in the equilibrium transmitter release as a function of stimulation frequency. The increase in the releasable pool was measured by applications of hyperosomtic solution immediately after a train of action potentials. The outputs of simulations were in a good agreement with the experimental data. The simulations demonstrated that the growth facilitation is mainly determined by the increase in the residual Ca2+, while plateau facilitation is determined by accumulation of releasable vesicles.

Neuromodulatory control of rhythmic neural activity in the Tritonia swim central pattern generator	Temporal structure in the bursting activity of the leech heartbeat CPG neurons
Robert Calin-Jageman Tuesday Poster – T50 Paul S Katz William N Frost	Doris Campos Monday Poster – M59 Carlos Aguirre Eduardo Serrano
Department of Biology, Georgia State University, Atlanta, Georgia, USA	Francisco de Borja RodrÌguez Gonzalo G. de Polavieja Pablo Varona
rcalinjageman@gsu.edu pkatz@gsu.edu	GNB. EPS. Universidad AutÛnoma de Madrid, Madrid, Spain
The Tritonia escape swim central pattern generator (CPG) is a network oscillator that contains a set of serotonergic neurons which function both as members of the CPG and as intrinsic neuromodulators that can rapidly alter many of the cellular and synaptic properties of the network. Here we attempt to understand the role of this intrinsic neuromodulation in the CPG is production of rhythmic bursting during swim motor programs. We drew upon two computational models of the circuit. One developed by Frost et al. (1997) representing an unmodulated state of the CPG and a second developed by Getting (1989) now known to represent a modulated state of the CPG. The rested (Frost) and modulated (Getting) models have identical topologies, but the rested model is substantially different in cellular and synaptic properties and does not produce rhythmic bursting when activated. We conducted a large-scale parameter analysis of iblendsî between these models by identifying 9 dimensions along which they differed and then varying each dimension from rested (Frost) to modulated (Getting) in 5 steps ( $59 = ~1.9 \times 106$ network configurations). We	doris.campos@uam.es carlos.aguirre@uam.es Neural signatures are cell-specific interspike interval distributions found in bursting neurons. These signatures have been first described for the neurons of the pyloric CPGs of crustacean. Their functional role is still unknown and their presence in other systems has not been shown yet. In this paper we analyze the interspike interval distribution of bursting neurons of the leech heartbeat CPG. We discuss the characteristics of the neural signatures found in this circuit.
found that the production of rhythmic bursting similar to a swim motor program is gated by two conditions, and that gating properties are set by the level of recurrent excitation within the network. Additionally, we observed a tendency for swim motor programs to be spontaneous and self-sustaining. This suggests	Predicting the Existence and Stability of 2P Modes in 2 Neuron Networks From Phase Resetting Curves Carmen Canavier Carmen Canavier Carbon Vielander Carbon Vielander Ca
that neuromodulation may play a role in shifting the network in and out of a bursting state, transiently creating a network oscillator.	Selvakumar Selandipalayam LSU Health Sciences Center, New Orleans, Louisiana, USA
The computation of the vulnerable phase in a model of Hodgkin-Huxley neuron	ccanav@lsuhsc.edu
Dragos Calitoiu Tuesday Poster_T24	sselan@lsuhsc.edu
Dragos Calitoiu Tuesday Poster –724 Carleton University, Ottawa, Canada dcalitoi@scs.carleton.ca In several neurological diseases like Parkinsonis disease or essential tremor, brain function is severely impaired by synchronized processes. The neurons fire in a synchronized periodical manner at a frequency similar to that tremor. Stimulation techniques have been developed for desynchronizing these neuronal populations, one of them, the Electrical deep brain stimulation (DBS) being performed by administering a permanent high frequency periodic pulse train via the depth electrodes. The DBS method was developed empirically, and its mechanism is not yet understood. The goal of suppressing the neuronal populations, one of them, the Electrical deep brain stimulation (DBS) being performed by administering a permanent high frequency periodic pulse train via the depth electrodes. The DBS method was developed empirically, and its mechanism is not yet understood. The goal of suppressing the neuronal population of the vulnerable state of a neuron can be used to generalize the result to population of neurons. A desynchronizing pulse in effectively only if it hits cluster of neurons in a very precise vulnerable phase. The existence of a vulnerable phase was predicted theoretically by Teorell (1971) for a two-variable model. He showed that we could achieve the annihilation of firing using a small brief test pulse injected into the refractory period just prior to the neuron attaining its firing level. Later, the annihilation of the spike train using a carefully chosen stimulus was predicted by Rinzel and also by Best (in 1979). Rinzel calculated periodic solutions to the space-clamped HH equations for a constant applied depolarizing current. The computational analysis of Best stated that one could ishockî the HH neuron out of the repetitive provid suing a properly timed instantaneous current pulse. Guttman, Lewis and Rinzel (1980) also confirmed experimentally that repetitive firing in a space- clamped squid axon bathed in low	Inhibitory interneurons play an essential role in the generation and control of synchronous oscillations in brain. In heterogenous networks, instead of exact synchrony, nearly synchronous modes arise. In the simplest inhibitory network consisting of two reciprocally coupled neurons, these nearly synchronous modes include 1:1 phase-locking at small phases (firing times that differ by less then about 10% of the network period) and "varied phase-locking" in which the interval between the firing of the two neurons is not the same every cycle, but rather constitutes a pattern that repeats every two cycles or more cycles. Existence and stability criteria for 2:2 steady phase-locked period two (2P) modes in reciprocally coupled two neuron circuits were derived based on the open loop phase resetting curve (PRC) of the component neurons using synaptic input as the perturbation. The main assumption is that each neuron returns close to its unperturbed cycle before its next input is received, thus allowing the application of PRC curves generated in the open loop configuration to prediction of closed loop network activity. The synaptic coupling in inhibitory networks has a time constant on the order of a few ms, hence a synaptic input delivered shortly before an action potential is fired can still be active after the action potential and therefore its influence can span two cycles. Therefore the PRC methods must take into account resetting that occurs in the cycle that contains the perturbation (first order) and the next cycle (second order). A regime of 2P modes in the network composed of two Wang and Buzsaki models coupled as in Skinner et al (2005) was examined, and the method correctly predicted the parameter regime in which the 2P mode is exhibited. However, there is a small error in the absolute values of the stimulus and recovery times, indicating that in practice there may be some deviation from the assumptions upon which the method rests. This approach can easily be extended to nP modes and can provide insight into

### Modelling Neural Systems with Catacomb 3

Sunday Poster -S40

Robert Cannon, Randal Koene, Michael Hasselmo Cantanout Limited, Center for Memory and Brain, Boston Univ. Edinburgh, UK robert@cantanout.com, randalk@askja.bu.edu

Catacomb 3, www.catcmb.org, is a combined graphical and textual modelling system for defining and running models on a range of scales from ion channel kinetics through cell and population activity to whole animal behaviours such as locomotion. It is focused on the the process of converting mental or written models into formal specifications and designs that can then be run on a computer. In particular, it breaks up the complex step from having an idea and some data to writing an actual implementation (simulator script or program) into smaller steps that can be addressed by separate individuals. In the first substep, all models are expressed declaratively as a set of linked or nested parameter tables. This can be done in text or graphically (e.g. attaching probes to a cell or setting up a channel transition scheme) according to which is most convenient. Importantly, this step is not restricted to the use of structures that have already been defined within the system. The user can define entirely new structures, including specifying their visual representation and connections for graphical modelling. The newly defined structures can be used just like existing structures for model building, still without introducing any aspects of traditional programming. How a model can be run depends on what implementations are available for the components it uses. As yet, these take the form of real Java classes. The classes can contain the executable instructions to advance the model directly, or can call other systems or simulators. A third flavour, involving fragments of scripts to express the relevant equations is under development. There are several advantages to separating model specification from implementation in this way. Removing the programming element allows people who best understand what needs to be modelled to make up the specifications. Having firm specifications then makes it much easier for programmers to implement the right thing. Allowing multiple implementations for the same model makes it easy to test the alternatives or to switch between levels of description. And the option of writing a custom implementation for any level in the model means that efficiency of calculations can be improved up to that of compiled code wherever needed without departing from the overall structure or modelling environment.

# Human theta oscillations associated with effective study of structured information

Jeremy Caplan Monday Poster – M105 Mackenzie Glaholt, Anthony R. McIntosh Rotman Research Institute, Baycrest, Toronto, ON, Canada, jcaplan@rotman-baycrest.on.ca, mglaholt@rotman-baycrest.on.ca.

Theta oscillations (e.g., Bland 1986), one of the chief features of the EEG, have long been implicated in memory encoding. Beyond simply facilitating memory for items (e.g., recalling a shopping list in any arbitrary order), some models implicate theta in memory for structured information, namely, paired associates and sequences of items, including spatial paths (e.g., Touretzky and Redish 1996) and verbal memory (e.g., Jensen, Idiart and Lisman 1996). Experimental evidence in non-human animals has revealed some support for this hypothesis (e.g, O'Keefe and Recce 1993; Seager et al. 2002). However, strong evidence for the specific function of theta oscillations in memory for pairs or lists of items has not been reported. Further, measurements of theta oscillations in humans are generally indirect, either simply frequency-domain analyses that could reflect non-rhythmic Fourier signal features or else based on subjective observation, as in work on frontal midline theta (e.g., Inanaga 1998; Inouye et al. 1993; Jensen and Tesche 2002; Mizuki et al. 1980). Caplan et al. (2001) introduced a method for automatically detecting episodes of oscillatory activity that accounts for the coloured-noise background spectrum and is consistent with visual inspection. Here the method is applied to extracranial EEG data while participants studied pairs (associations) and triples (brief ordered sequences) of words for a subsequent cued recall test. The oscillatory episode-detection algorithm identified scalprecorded EEG segments that, by visual inspection, appeared as rhythmic theta activity without the need for bandpass filtering. Multivariate, partial least-squares analysis (McIntosh 1996) identified a pattern of such oscillations including prominent frontal theta as well as more posterior beta-band oscillations that accounted for individual variability in recall of pairs and triples. These findings extend recordings of frontal midline theta including Summerfield and Mangels' (2005) finding that frontal theta covaries with subsequent recognition of word-colour pairs, suggesting that this rhythmic activity may support learning of a general class of structured information. This supports a subset of models of the relational function of theta which may generalise to brain regions outside the hippocampus. They are also reminiscent of other findings of theta activity covarying with individual differences in memory (e.g., Doppelmayr et al. 2000) suggesting that theta oscillations reflects a subject-level variable in memory encoding processes.

### Quantified Symmetry for Entorhinal Spatial Maps

Erick Chastain, Yanxi Liu

Carnegie Mellon University, School of Computer Science Pittsburgh, Pennsylvania, USA

echastai@cnbc.cmu.edu, yanxi@cs.cmu.edu

General navigation requires a spatial map that is not anchored to one environment. The firing fields of the "grid cells" found in the rat dorsolateral medialentorhinal cortex (dMEC) could be such a map.dMEC firing fields are also thought to be modeled wellby a regular triangular grid (a grid with equilateral triangles as units). We use computational means to analyze and validate the regularity of the firing fields both quantitatively (using summary statistics for geometric and photometric regularity) and qualitatively (using symmetrygroup analysis). Upon quantifying the regularity of real dMEC firing fields, we find that there are two types of grid cells. We show rigorously that both are nearest to triangular grids using symmetry analysis. However, type III grid cells are far from regular, both in firing rate (highly non-uniform) and grid geometry. Type III grid cells are also more numerous. We investigate the implications of this for the role of grid cells in path integration.

## A feed-forward model of spatial and directional selectivity of hippocampal place cells

Ricardo Chavarriaga Tuesday Poster –T4 Denis Sheynikhovich, Thomas Strösslin Wulfram Gerstner, IDIAP Research Institute, Ecole Polytechnique FÈdÈrale de Lausanne Martigny, Switzerland ricardo.chavarriaga@a3.epfl.ch, denis.sheynikhovich@epfl.ch

We have developed a model of hippocampal place cells, which reproduces both spatial and directional selectivity of these cells. In our model, place cells are intrinsically directional (responding to specific local views), and their directionality is reduced during exploration when the rat is not constrained in the direction of its movements (like in open fields or the centre of mazes). We have modelled changes in the place cell directionality as the result of experiencedependent changes (through unsupervised Hebbian learning) in feed-forward connections from a population coding for specific local views. When the animal is able to explore the same location with different head directions, it allows a single post-synaptic cell to be connected to pre-synaptic cells coding for several local views. Therefore, the directional selectivity of that cell is reduced. Previous models of directional selectivity of place cells (Brunel and Trullier, 1998; Kali and Dayan, 2000) suggest that this property is a product of changes in recurrent connections among place cells. Such models have proposed the recurrent network in CA3 as the putative locus of directional changes in the hippocampal place code. However, recent experimental data (Brun et al., 2002; Fyhn et al., 2004) suggests that a functional CA3 is not required to produce changes in the directionality of both entorhinal and CA1 cells. This supports our assumption that feed-forward projections onto the hippocampus may suffice to yield directional changes in the PC activity.

# Empirical lower bound of the number of fix points of an attractor neural network

Joel Chavas Nicolas Brunel Tuesday Poster -T46

ISI Foundation, Torino, Italy chavas@isiosf.isi.it,nicolas.brunel@univ-paris5.fr

The scope of the work is to determine empirically a lower bound on the number of fix points in a neural network, even in the case in which analytical methods are not applicable. Do the number of fix points scale exponentially with the size of the network, or can it scale polynomially with it ? The method is first illustrated in the case of the {-1,1} Hopfield neural network : by imposing a random initial condition on the neurons, the network converges towards a fix point. The average Hamming distance between the random initial condition and this final state of the network. The method shows that, for all values of a>0 (a\*n being the number of learned patterns), there is at least an exponential number K\*exp(S\*n) of fix points. S scales as S=0.1127\*a^1.3073. The method is generalizable to continuous neural networks.

Phase locking states of a pair of coupled inhibitory interneurons	Glomerular computations for normalization in the olfactory bulb	
Santi Chillemi Tuesday Poster –T34 Michele Barbi, Angelo Di Garbo CNR-Istituto di Biofisica, Pisa, Italy <u>santi.chillemi@pi.ibf.cnr.it</u> , michele.barbi@pi.ibf.cnr.it	Thomas Cleland Monday Poster – M85 Brett Johnson Michael Leon	
The synchronization properties of a pair of interneurons coupled by electrical and inhibitory synapses are investigated by using a realistic time course of the inhibitory postsynaptic current. The results, obtained in the weak coupling limit, shows that the values of the rise and decay time constants characterizing the dynamics of the inhibitory current, affect the synchronization properties of the cells. Moreover, we show that the presence of the electrical coupling promotes synchronization. Computing with Active Dendrites	Neurobiology & Behavior, Cornell University, Ithaca, New York, USA tac29@cornell.edu,bajohnso@uci.edu The perceptual quality of odors is robust to substantial variability in their concentrations. This is a critical property for a sensory system, as it is vital that odor stimuli can be recognized even when encountered at highly variable and unpredictable intensities. However, maps of neural activation across the glomerular layer of the olfactory bulb reveal monotonic increases in the breadth and intensity of odor representations as the concentrations of odor stimuli are	
Panchev Christo School of Computing and Technology, University of Sunderland Sunderland, UK christo.panchev@sunderland.ac.uk This paper introduces a new model of a spiking neuron with active dendrites and dynamic synapses (ADDS). The neuron employs the dynamics of the synapses and the active properties of the dendrites as an adaptive mechanism for maximising its response to a specific spatio-temporal distribution of incoming action potentials. The paper also presents a new Spike-Timing-Dependent Plasticity (STDP) algorithm developed for the ADDS neuron. This algorithm follows recent biological evidence on synaptic plasticity, and goes beyond the current computational approaches which are based only on the relative timing between single pre- and post-synaptic spikes and implements a functional dependence based on the state of the dendritic and somatic membrane potentials at the time of the post-synaptic spike.	increased, a simple representation that offers no clear means of mediating the concentration-independent identification of odor quality and is at odds with the results of behavioral discrimination experiments. As ratios of glomerular activation are roughly concentration-independent, it has been suggested that these relative activation profiles are the mediators of odor quality ñ i.e., that incoming olfactory representations must be normalized to a consistent scale. Additionally, contemporary models of olfactory contrast enhancement in high dimensions require a normalizing feedback loop with minimal variance across the olfactory bulb glomerular layer. Using activity profiles drawn from the rat olfactory bulb in combination with computational modeling of olfactory bulb circuitry, we here show that (1) normalization preserves concentration-independent odor quality information, (2) perceptual similarities, as assessed behaviorally, are better predicted by normalized than by raw bulbar activation profiles, and (3) that the lateral excitatory interneuronal network recently described in the olfactory bulb is capable of delivering uniform feedback inhibition across the bulb. We show for the first time that global feedback normalization in a sensory system is behaviorally relevant.	
Spatial and temporal control mechanisms influencing signal integration in a CA1 pyramidal cell model	The role of onsets in auditory processing       Monday Poster – M71         Monday Poster - M71       Monday Poster - M71	
Janette Clark, Bruce Graham Monday Poster – M36 University of Stirling, Stirling, Scotland, UK jcl@cs.stir.ac.uk, b.graham@cs.stir.ac.uk	Martin Coath Susan Denham University of Plymouth, Plymouth, UK	
Spatial and temporal control mechanisms influencing signal integration in a CA1 pyramidal cell model. Janette Clark and Bruce Graham. Email: jcl@cs.stir.ac.uk (J. Clark), b.graham@cs.stir.ac.uk.(B. Graham) Dept of Computing Science & Mathematics, University of Stirling, Stirling FK9 4LA, Scotland, UK The hippocampus is known to be crucially involved in associative memory function. In particular, the CA1 sub-region has been postulated as a suitable substrate for heterassociative episodic memory (Paulsen and Moser. Trends Neurosci 21(7):273-8, 1998). Precisely how it performs this memory task is not fully understood. Towards this goal, the signal integration properties of a model CA1 pyramidal cell are being explored. A detailed compartmental model of a hippocampal CA1 pyramidal cell that contains known channel types and distributions (Poirazi et al. Neuron 37(6):989-99, 2003) has been extended to exhibit a range of neuronal behaviours that have been observed in vitro and that are considered crucial if the cell is to act in its purported role as an associative memory unit. The dual resonance behaviour seen by Hu et al (J Physiol 545( Pt 3):783-805, 2002) has been achieved by redefining and redistributing M- and H- and NaP channels. The persistent sodium current (NaP) has also been tuned to provide the action potential after-potential (ADP) seen by Yue et al (J Neurosci 25(42):9704-20, 2005) and the associated bursting behaviour. The model has then have used to tat the neutrom reasonition.	mcoath@plymouth.ac.uk, sdenham@plymouth.ac.uk Enhancement of auditory transients is well documented in the auditory periphery and mid-brain, and single unit investigations have identified units with responses which may underly this sensitivity. It is also known that transients are important in psychophysics in, for example, speech comprehension and object recognition and grouping. In this work we first introduce a simple phenomenological model of auditory transient extraction, based on the skewness of the distribution of energy inside a frequency dependent time window, and show that this view is consistent with electrophysiological measurements of auditory brainstem responses. Second, by analyzing properties of the autocovariance of this representation we present evidence that onset enhancement may provide a positive biological advantage in processing classes of sound that are behaviourally relevant. Lastly, we show that spectro-temporal response fields, which are estimated by reverse correlation with spectrographic, or cochleagraphic descriptions of the sounds, can also be derived from patterns of onsets and offsets i.e. a representation that discards information about the energy present at any time in a frequency band.	
behaviour. The model has then been used to test the pattern recognition capabilities of such a biologically realistic cell. This work extends previous research by Graham (Network 12(4):473-92, 2001) by exercising his findings in a more complex and morphologically different cell. The latter facilitates an investigation into the significance of the spatial location of synapses on signal integration within CA1 pyramidal neurons. Further, the model allows an exploration into the role of specific somatic and dendritic ion channels on signal propagation within the cell, in particular IA, IM, IH and INap. Results so far indicate the pattern recognition capabilities of different pyramidal cells are influenced by their morphology. Further, the active properties of this cell, tuned to a variety of experimental data, are not necessarily optimal for the form of pattern recognition we have investigated. It remains to be determined what	Persistence of activity in an isolated neuron       Tuesday Poster –T14         Simona Cocco       CNRS-L PS, Ecole Normale Superieure, Paris, France         simona.cocco@lps.ens.fr       The persistence of activity in an isolated and auto-connected neuron (autapse) is studied. An Integrate-and-Fire model and an Hodgkin-Huxley model, based on the auto-stimulating currents observed in experiments, and including a noisy synaptic release and a Calcium dependent adaptation current are proposed. The distributions of inter-spikes intervals and burst durations are calculated through	
adjustments might be required to improve the pattern recognition performance of this cell. We have already seen that a reduction in the A-current may help.	transfer matrix and generating function techniques, and show a good agreement with experimental data and simulations.	

Animatlab: A Physically Accurate 3-D Environment for Behavioural Neurobiology Research	Neurospaces : towards automated model partitioning for parallel computers	
David Cofer Sunday Poster – S39 James Reid Oleksiy Pochapinskyy	Hugo Cornelis Sunday Poster –S42 Erik De Schutter	
Ying Zhu Gennady Cymbalyuk William Heitler	UTHSCSA, San Antonio, Texas, USA <u>hugo.cornelis@gmail.com</u> , erik@tnb.ua.ac.be	
Donald Edwards Georgia State University, Atlanta, Georgia, USA	Parallel computers have the computing power needed to simulate biologically accurate neuronal network models. Partitioning is the process of cutting a model in pieces and assigning each piece to a CPU. Automatic partitioning algorithms	
dcofer1@student.gsu.edu jreid3@student.gsu.edu	for large models are difficult to design for two fundamental reasons. First, the algorithms must track the intrinsic asymmetries in the models and the dynamical behavior of the simulation. Second, the procedural nature of current modeling languages make it difficult to extract the information needed by the algorithms. From the start, the Neurospaces modeling system has been designed to deal with large and complicated neuronal models. The declarative nature of the software system allows to extract any kind of information from the model. In this work we show the first steps for automated model partitioning. First, we show how to extract the information to compute a possible partitioning for a small and a large network model. Our future plans include to embed the described algorithm in the Neurospaces modeling system.	
Understanding neural mechanisms of behavior has frequently depended on comparisons between detailed descriptions of freely behaving animals and fictive motor programs displayed by neurons in anesthetized, restrained, and dissected preparations. We have developed a software toolkit, AnimatLab, to help researchers determine whether their descriptions of neural circuit function can account for how specific patterns of behavior are controlled. AnimatLab enables one to build a virtual body from simple LEGOô-like building blocks, situate it in a virtual 3-D world subject to the laws of physics, and control it with a multicellular, multicompartment neural circuit model. A body editor enables		
adjustable blocks, balls, truncated cones, and cylinders to be connected through a variety of joints to form a body. Sensors enable extrinsic and intrinsic signals to be detected, and virtual muscles governed by Hill muscle models span the	Neural Automata: the effect of microdynamics on unstable solutions	
joints to produce movement. The body and other objects are subject to gravity, buoyancy, drag, friction, contact collision, and muscle tension. A neural editor enables a neural network to be constructed from a menu of neurons and	Jesus M Cortes Tuesday Poster –T21 B. Wemmenhove, Joaquin Torres J. Marro, H. J. Kappen	
synapses, and then linked to sensors and effectors on the body. We are currently using AnimatLab to study the neural control of locomotion and the escape behavior of crayfish. High-speed video will be used to record the escape	Institute for Adaptive and Neural Computation, Edinburgh, UK jcortes1@inf.ed.ac.uk, b.wemmenhove@science.ru.nl	
movements in 3D. From this the forces and torques required to produce that motion can be calculated and used to guide the construction of the simulated escape response. Differences between the real and simulated responses will help identify gaps in our understanding of the dynamic control of escape.	We presented neural automata in which the number of neurons which are synchronously updated at each time step, namely n, may vary from one to the total number of neurons. We obtained a theoretical description for the macroscopic dynamics which is in full agreement with Monte Carlo simulations. This kind of automata is a general scenario to understand how unstable solutions propagate in different way depending on microdynamics and	
Neural population information related to localization versus feature extraction of complex stimuli	controlled by n. However, the effect of changing n on stable solutions is irrelevant, e.g. just rescales the time step in the dynamics.	
J-Olivier Coq Monday Poster –M90 Céline Rosselet Christian Xerri Jean-Luc Blanc	Stability and robustness in an attractor network are influenced by degree of morphology reduction	
UMR 6149 Neurobiol Integrative & Adaptative CNRS - Univ. de Provence, Marseille, France	Patrick Coskren Sunday Poster – S97 Patrick Hof, Susan Wearne	
coqjo@up.univ-mrs.fr celine.rosselet@up.univ-mrs.fr	Mt. Sinai School of Medicine, Flushing, New York, USA pcoskren@mac.com, patrick.hof@mssm.edu	
To understand how information is coded in the primary somatosensory cortex (S1), we need to decipher the relation between neural activity and tactile stimuli. Such a relation can be rigorously measured by mutual information. The present study was designed to determine how S1 neuronal groups code for the multidimensional kinetic features of complex tactile stimuli, which were applied at different locations. More precisely, the stimulus localization and feature extraction were analyzed as two independent or synergistic processes. Using a multielectrode acquisition system, we recorded the activity of S1 neuronal populations induced by complex stimulus feature extraction process, multidimensional stimuli were projected onto lower dimensional subspace and then clustered with k-means. Information analyses show that both processes are synergistic and that stimulus localization process is faster than feature extraction. Therefore, combining mutual information analysis with robust clustering of complex stimuli provides a framework to study neural coding of natural stimuli.	Dendritic morphology of pyramidal cells is known to affect firing behavior. Despite this, most network models disregard morphology or model it only as a icoupling conductanceî connecting point representations of a soma and a dendritic tree. The question of how dendritic morphology shapes the activity of networks is an area of active research. One method of study is to build networks with cell properties determined by morphology; the morphology can then be perturbed and the effects on the networks functional properties compared. In the present study, a discrete attractor network model of associative working memory is used to evaluate two different reduced models of the same layer 2/3 mouse neocortical pyramidal neuron. The attractor states of such networks model stored memories. This suggests two natural measures of network function: stability, defined as the weakest network input required to divert the network state from one of its attractors, and robustness, defined as the ability of the system to maintain mnemonic function despite changes to the network parameters. Using a novel measure of both properties termed a istability manifoldî, early results demonstrate the insufficiency of a minimalist 3- compartment neuron for studying the effect of detailed morphology on network function. These results demonstrate the importance of accounting for morphological factors in assessing the global stability and robustness of attractor network models of working memory.	

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#### Effects of Na+ channel inactivation kinetics on metabolic energy costs of Investigating seizures with reduced models of potassium dynamics action potentials Sunday Poster -S63 John Cressman Jokubas Ziburkus, Ernest Barreto, Steven Schiff Patrick Crotty Monday Poster -M20 William Levy Krasnow Institute, George Mason University, Fairfax, Virginia, USA jcressma@gmu.edu, jziburku@gmu.edu CNS, Charlottesville, Virginia, United States prc9m@virginia.edu Experiments have demonstrated that 4-aminopyridine-induced seizures in the rat hippocampus are characterized by an initial excessive firing and subsequent wbl@virginia.edu period of depolarization block (DB) in inhibitory cells. We present models that We analyze the effects of sodium channel inactivation kinetics on the metabolic replicate seizure dynamics while utilizing a minimal number of equations and parameters. These models are based on the modulatory effects of changes in energy cost incurred by an action potential in a squid giant axon. This energy extracellular and intracellular environment, namely potassium concentrations. cost can be divided into three separate components. The component associated These models predict that alterations to potassium conductances as well as glial with the rising phase of the action potential shows very little dependence on the and pumping mechanisms can lead to spontaneous seizures. inactivation kinetics, which are parameterized by the inactivation voltage dependence and the overall normalization of the inactivation rate. The largest energy component, which is associated with sodium and potassium currents that Time-warp invariant stimulus decoding in an insect auditory system? cancel each other out and so have no electrical effect, shows a much stronger dependence. In general, faster inactivation at higher depolarizations leads to a Felix Creutzig Sunday AM Oral substantial reduction in energy costs, but can also inhibit the ability of the axon Sandra Wohlgemuth, Jan Benda to repolarize fully after an action potential. The question of whether evolution Andreas Stumpner, Bernhard Ronacher, Andreas V.M. Herz has optimized sodium channel inactivation kinetics (assuming that they are

Institute for Theoretical Biology, HU Berlin

Bernstein Center for Comp. Neurosci. Berlin, Berlin, Germany felix@creutzig.de, sandra.wohlgemuth@rz.hu-berlin.de

Female grasshoppers of the species Chorthippus biguttulus respond to male mating songs that consist of specific syllable-pause patterns. Behavioural experiments with artificial stimuli show that the female reaction is not determined by the absolute syllable length but by the ratio between syllable and pause length, thus performing time-warp invariant stimulus recognition. We studied the role of a single auditory ascending neuron (AN12) in processing natural and artificial mating songs. We show that this neuron encodes the length of relative quietness before a syllable by spike count within bursts. A simple integrate & fire neuron model with two input channels, one instant excitatory and one inhibitory with exponential kernel can explain this behaviour. Integration of the neuron's spike train in response to songs over a fixed time effectively multiplies average pause length and syllable frequency and, hence, provides a time-warp invariant presentation of the song pattern.

# Facilitating Software Interoperability and Model Exchange: XML Standards for Model Specification

Sharon Crook, Padraig Gleeson Sunday Poster –S54 Arizona State University, Tempe, Arizona, USA sharon.crook@asu.edu, p.gleeson@ucl.ac.uk

The Neural Open Markup Language project, NeuroML, was initiated due to growing interest in describing and exchanging neuroscience data and neuronal model information using eXtensible Markup Language (XML) technology. We describe newly developed NeuroML standards for neuroanatomical data and associated neurophysiological membrane properties, which are intended as a common data format for the representation of biologically realistic neuronal models. These standards facilitate model archival and model publication, but they also provide a common data format for communication among modelingrelated tools. The first level of standards within NeuroML describes only the anatomical aspects of neuronal data such as cell morphology and fiducials used for registration and alignment to a common coordinate system. Because NeuroML Level 1 can be used as a stand-alone schema for neuroanatomical data, it is also referred to as MorphML. Note that by including cell structure explicitly using self-describing language elements, relevant data representing cell membrane properties can be linked to the morphology data representing a particular structure. For example, values for membrane resistance and capacitance as well as information about ion channels can be associated with a portion of the dendrite of a neuron. This is the approach used in NeuroML Level 2 for representing all of the information that is needed for creating models for simulating cell behavior. We have developed a web-based application that will validate an XML document against the schemata for NeuroML Level 1 and Level 2. The NeuroMLValidator and detailed examples of valid documents that specify the biological details for realistic neuronal models are available on our website. These NeuroML standards are being used extensively for model specification in applications. Examples include neuroConstruct, the Virtual RatBrain Project, and future versions of GENESIS and NEURON.

### Regulation of bursting activity of simple units of CPGs

easily evolvable) will probably have to take the information rate into account as

Gennady Cymbalyuk Ronald Calabrese Andrey Olypher Andrey Shilnikov

well as energy.

Monday Poster -M16

Dept of Physics and Astronomy, Atlanta, Georgia, USA gcym@phy-astr.gsu.edu, rcalabre@biology.emory.edu

Bursting is an oscillatory activity consisting of intervals of repetitive spiking separated by intervals of quiescence. It is an important mode for control of rhythmic movements and is frequently observed in central pattern generators (CPG), neuronal networks controlling motor behavior. One feature commonly observed in these networks is the ubiquitous appearance of mutually inhibitory connections between neuronal units, where the neuronal unit can be either a single neuron or a group of neurons (half-center oscillator). We consider single neurons and neurons in a half-center oscillator configuration as simple units of CPGs. Our research is focused on determining the generic biophysical and bifurcational mechanisms underlying regulation of the temporal characteristics of bursting activity. Here we identify two groups of such mechanisms. (1) Variation of time constants of certain ionic currents can directly control temporal characteristics of bursting activity. In our experimental study, we focused on the role of the slowly inactivating low-threshold Ca current in the generation of the activity pattern. Here we describe a completed series of experiments with a half-center oscillator assembled as a hybrid system from a living leech heart interneuron and its canonical mathematical model running in real time. We varied the inactivation time constant unilaterally in either a living cell or in the model counterpart and assessed the changes in major characteristics of the bursting waveform generated by the hybrid system: burst duration and period. Our results show that the inactivation variable of slowly inactivating low-threshold Ca current plays the key role in determining the time course of the frequency decaying towards the end of the burst frequency and the variation of influences the duration of the burst phase of the neuron which was the subject to the variation. (2) The ways in which bursting activity arises from tonic spiking or quiescence regimes may determine the evolution of temporal characteristics of bursting pattern in response to progressing changes of a controlling parameter. Bifurcation analysis of the dynamics of neurons under pharmacological reductions allows one to study comprehensively the general mechanisms of metamorphoses of temporal characteristics of the neuronal activity. It provides the qualitative and quantitative description of the evolution of waveforms on a control parameter. Results are compared to the complete 14D model of the heart interneuron and to other models under different pharmacological reductions and in a half-center oscillator configuration. Supported by NIH grant NS-043098 and by grant from the GSU Brains and Behavior program.

A combined pyschophysicalmodelling investigation of the mechanisms of tactile picture perception		Mechanisms underlying the development of synchrony: a comprehensive approach	
Andrew Davison	Tuesday Poster –T75	Jaime de la Rocha	Tuesday PM Oral
Pierre Yger, Jason Chan, Fiona New	vell,Yves FrÈgnac	Brent Doiron	
		Eric Shea-Brown	
UNIC, CNRS UPR 2191		Kresimir Josic, Alex Reyes	
Centre National de la Recherche Sc	ientifique, Gif sur Yvette, France		
		New York University, New York, New York, USA	
andrew.davison@iaf.cnrs-gif.fr			
pierre.yger@iaf.cnrs-gif.fr		jaime.delarocha@nyu.edu, bdoiron@cns.nyu.edu	

The involvement of visual cortex in haptic spatial perception, including haptic object recognition, is well established, but little is known about the precise mechanisms involved. We have pursued a joint experimental-modelling approach to explore possible mechanisms. Human exploratory paths in a task involving tactile picture perception are used to drive a system-level model of haptic processing, based on the idea that humans continuously compare tactile and proprioceptive sensory input to multiple hypotheses about the contents of the picture. Each hypothesis is represented as a mental image, expressed as a pattern of activation in visual cortex representing the expectation of finding particular tactile features at particular points in space. The simulated responses of the model show good agreement with human performance when averaged over subjects, although we are unable to match performance on a subject-by-subject basis.

#### An efficient solution for the population density equation

Marc de Kamps Frank van der Velde Sunday Poster -S61

TU Munich - Dep. of Informatics, Munich, Germany

kamps@in.tum.de, vdvelde@fsw.leidenuniv.nl

Knight and co workers (1996) introduced a novel population density technique, which describes the behaviour of a large population of spiking neurons in response to a stochastic input. Although such techniques have been around for decades, there are several aspects which make their approach interesting. For example, it is possible to transform away neuronal dynamics, which leaves the master equation of a Poisson point process. Although this does not lead to an analytic solution, because the input parameters of this equation become dependent on the neuronal dynamics, the master equation translates into a set of ordinary equations, in which gradients of the population density are no longer present. For leaky-integrate-and-fire (LIF) dynamics, there are essentially two time scales: the membrane time constant and the inverse of the synaptic input rate. For cortical neurons the latter may be much faster than the former. In this case the master equation may be used over time intervals which are large with respect to the inverse of the synaptic input rate, but short compared to the membrane time constant. Here an analytic solution for the master equation can be useful. A formal solution of this equation was provided by Sirovich (2003). Here we present the full solution, and use it to solve the population density equation. The resulting algorithm is manifestly stable and efficient in the face of rapidly varying input. A disadvantage is that a delta distributed synaptic efficacy is assumed, but for cases where Gaussian white noise inputs are emulated, this is not a problem. The efficiency and stability of the method make it suitable for modelling in large-scale networks of cognitive models and may be a step forward in the direction of predicting fMRI and EEG signals on the basis of cognitive models.

To elucidate the conditions under which synchrony develops in a neural circuit, we study the emergence of synchrony in a system composed of a pair of cells stimulated by an excitatory and an inhibitory populations. We study the impact of common inputs between the two target neurons and correlations across presynaptic cells in the generation of output synchrony. We use an integrateand-fire model neuron to obtain analytical expressions for the afferent correlations as a function of the parameters describing the presynaptic activity. We first found that common inputs are little effective synchronizing the target cells. On the other hand input synchrony has a enormous impact generating correlations in the responses. However, correlations among excitatory and inhibitory cells have a subtractive effect and may cancel the impact of correlations among excitatory cells and among inhibitory cells. This cancellation implies a balance between excitation and inhibition beyond their means: it is a temporal balance in the arrival of synchronous excitatory and inhibitory events. We finally compute a simple analytical formula which expresses the output correlation coefficient r as a function of known statistics such as the output firing rate and the output coefficient of variation of the inter-spike-intervals. This formula is valid in the regime of weak input and output correlations in which r depends linearly on the afferent correlations. We define the synchronization susceptibility as the gain of this mapping. Surprisingly, we found that this susceptibility scales with the output firing rate. This implies that two cells firing at low firing rates are less susceptible of becoming correlated than if they were firing at higher rates. These ideas are presently being tested using paired recordings in cortical mouse slices. Our results will serve to clarify under which circumstances synchrony is more susceptible to develop in an ensemble of neurons, something that has important implications on the transmission of neural signals.

# Decision-Making and Weber's Law: Finite Size Fluctuations in Spiking Dynamics

Tuesday Poster -T76

Gustavo Deco Edmund Rolls Universitat Pompeu Fabra, ICREA, Barcelona, Spain gustavo.deco@upf.edu, edmund.rolls@psy.ox.ac.uk

Behavioral, neurophysiological, and theoretical studies are converging to a common theory of decision-making that assumes an underlying diffusion process which integrates both the accumulation of perceptual and cognitive evidence for making the decision and motor choice in one unifying neural network. In particular, neuronal activity in the ventral premotor cortex (VPC) is related to decision-making while trained monkeys compare two mechanical vibrations applied sequentially to the tip of a finger to report which of the two stimuli have the higher frequency (Romo et al. 2004, Neuron 41: 165). In particular, neurons were found whose response depended only on the difference between the two applied frequencies, the sign of that difference being the determining factor for correct task performance. We describe an integrate-andfire attractor model with realistic synaptic dynamics including AMPA, NMDA and GABA synapses which can reproduce the decision-making related response selectivity of VPC neurons during the comparison period of the task Populations of neurons for each decision in the biased competition attractor receive a bias input that depends on the firing rates of neurons in the VPC that code for the two vibrotactile frequencies. It was found that if the connectivity parameters of the network are tuned, using mean-field techniques, so that the network has two possible stable stationary final attractors respectively related to the two possible decisions, then the firing rate of the neurons in whichever attractor wins reflects the sign of the difference in the frequencies being compared but not the absolute frequencies. Thus Weber's law for frequency comparison is not encoded by the firing rate of the neurons in these attractors. An analysis of the nonstationary evolution of the dynamics of the network model shows that Weber's law is implemented in the probability of transition from the initial spontaneous firing state to one of the two possible attractor states. In this way, statistical fluctuations due to finite size noise play a crucial role in the decision-making process.

Phase Synchronization between LFP and Spiking Activity in Motor Cortex
During Movement Preparation

Michael Denker Monday PM Oral SÈbastien Roux, Marc Timme, Alexa Riehle, Sonja Gruen Neuroinformatics, Inst Biology – Neurobiology, Free University Berlin, Berlin michael\_denker@gmx.de, sebastien.roux@incm.cnrs-mrs.fr

Cortical spiking activity is often recorded in parallel with the local field potential (LFP) from the same electrode. The LFP typically exhibits prominent oscillatory features and has been shown to display modulations that contain information about relevant behavior (Mehring et al., 2003). A current hypothesis describes increases in the amplitude of LFP oscillations as a consequence of synchronous synaptic activity of many neurons in a large volume near the electrode. Thus, it has been suggested that spikes occur preferably within a distinguished range of the phase during one oscillation period. It is argued that such a relationship between instantaneous LFP phase and spike time may be involved in the representation of information in networks (see, e.g., Friedrich et al., 2004). In this study we analyzed recordings from primary motor cortex of a behaving monkey in a time discrimination task (Roux et al., 2003). Preceeding the actual execution of the movement, the experimental design involved two periods in which different amounts of prior information about the upcoming movement were available. Previous work provides evidence that the dynamics observed in motor cortex are closely related not only to the movement itself, but also to movement preparation. Extending approaches from phase synchronization analyses (e.g., Lachaux et al., 1999), we employed a novel method that directly utilized the instantaneous phase of the LFP time series to measure the degree of phase coupling between the spike train and the oscillation cycle in a frequency-adaptive and time-resolved manner. The use of surrogate methods aids in rejecting periods of spurious coupling caused by regularity in the spike train. The observed locking periods of single LFP-unit pairs show a variety of different properties in terms of duration, strength and phase preference. In particular, we investigated the dependence of the precision of phase coupling on the different periods of a behavioral trial and its relation to LFP signals recorded from different electrodes. Furthermore, we tested the hypothesis that periods of increased LFP amplitudes lead to an increase of the degree of synchronization between the two signals. In addition, our results were linked to those obtained from two other methods that relate spikes and LFP, i.e. spike-triggered averages and spike field coherence. Acknowledgments: Supported by the Volkswagen Foundation, the Stifterverband f r die Deutsche Wissenschaft, and the Bundesministerium f r Bildung und Forschung (grant 01GQ0413 to BCCN Berlin).

#### Effects of stimulus transformations on estimated functional

Alexander Dimitrov Rony Azouz Tomas Gedeon Sunday Poster -S18

Montana State University, Bozeman, Montana, USA

alex@cns.montana.edu razouz@bgumail.bgu.ac.il

The functional properties of neural sensory cell or small ensembles are often characterized by analyzing response-conditioned stimulus ensembles. Many widely used analytical methods, like Wiener kernels or STRF, rely on simple statistics of those ensembles. They also tend to rely on simple noise models for the residuals of the conditional ensemble. However, in many cases the responseconditioned stimulus set has more complex structure. If not taken explicitly into account, it can bias the estimates of many simple statistics, and render them useless for describing the functionality of a neural sensory system. Here we the presence of two transformation-based noise sources in the rat vibrissal system: temporal jitter and temporal dilation invariance. We analyze the perturbations and correct their effect on the spike-triggered average.

### A model of illusory contour formation based on dedritic computation

Monday Poster –M41

Drazen Domijan Mia Setic Domagoj Svegar

Department of Psychology, University of Rijeka, Rijeka, Croatia

ddomijan@net.hr mia-setic@ffri.hr

Illusory (or subjective) contours are vivid percepts of lines between inducing elements which do not have support in physical stimulation. Grossberg and Mingolla (1985) proposed a model of bipole cells which can perform contour integration of nonadjacent line segments. However, the model was not able to capture several important findings about illusory contours. For instance, strength of the illusory contour varies with the number and relative size of inducing elements. Furthermore, the illusory contour is stronger with irregular placement of inducing elements rather than with regular placement. The illusory contour formation could be prevented by top-down or attentional signals. We propose a new model of bipole cells based on the properties of dendritic computation. Basic elements of the network are an excitatory cell with two dendritic branches and an inhibitory cell. The excitatory cell sends its signal to other excitatory cells whose receptive fields are collinear with it and therefore forming a recurrent excitatory network. Also it sends signal to other excitatory cells and to the inhibitory cell. Excitatory and inhibitory cells are modelled as continuoustime linear units with threshold. The inhibitory cell has two collaterals which contacts dendritic branches of the excitatory cell. Both dendritic branches behave as an independent linear unit with threshold. They summed all excitatory input from nearby collinear cells, and inhibition from one collateral of the corresponding inhibitory cell. Furthermore, output of dendritic branches multiplicatively interacts before it is send to the soma. Multiplication allows excitatory cell to be active only if both of its branches receive enough excitation to reach the threshold. Therefore, basic property of the bipole cell is achieved using dendritic multiplication. Computer simulations showed that presented model of the illusory contour formation is able to perform perceptual grouping of nonadjacent collinear elements. It shows linear response relationship with input magnitude because it computes MAX function of its input. Computation of MAX function is achieved using dendritic branches on excitatory cells which receive inhibition from corresponding inhibitory cell. Inhibition regulates signal flow and prevents unbounded growth of activity. The model can explain why illusory contours are stronger with the irregular placement of inducing elements rather than regular placement and why attention may prevents the illusory contour formation.

Modelling statistical processing of visual information		A Population Model of Generation of Vasopressin Release	
Drazen Domijan Mo Mia Setic Domagoj Svegar	onday Poster –M46	Ruth Durie Gareth Leng David Willshaw	Tuesday Poster –T57
Department of Psychology, University of Rijeka, Rijeka, Cu	roatia	Edinburgh University, Edinburgh, UK	
ddomijan@net.hr mia-setic@ffri.hr		ruthd@dai.ed.ac.uk gleng@staffmail.ed.ac.uk	
Recent psychophysical investigations showed that humans are able to compute mean size of a set of similar objects presented visually. They suggest that visual		Vasopressin neurons have been extensively studied, due importance and easily accessible position. They are unu	usual in that their purpose

system is able to form overall, statistical representation of a set of objects while information about individual members of the set is lost. Statistical analysis of size is performed in a fast and parallel manner without serial scanning. We proposed a neural model that computes mean size of a set of similar objects. The model is a feedforward two-dimensional neural network with three layers. The first layer is an input layer with binary representation where 0 indicates empty location and 1 indicates location occupied by an object. The second layer employs two mechanisms: gradient synaptic weights and dendritic multiplication. Signals from the first layer are differentially weighted depending on their spatial position in the network, that is, every location in the network has unique synaptic strength. Furthermore, input activity is summed from nearest neighbours and multiplied by corresponding node in the input layer. Multiplication prevents interference from nodes that do not represent objects but are active due to the activation in the neighbourhood. Both mechanisms are necessary for obtaining proper transformation from visual input to number representation as shown by computer simulations. The third layer implements local winner-take-all (WTA) mechanism where only locally most active nodes remain active and all other nodes are inhibited bellow threshold. This is a crucial step because it forms a representation of visual environment where a single node is active for a single object. Competition is realised using feedforward presynaptic inhibition whose physiological substrate is a transmitter spill-over. Computer simulations showed that presented model of statistical processing is able to compute mean size of a set of similar objects. This is achieved in a fast and parallel manner without serial scanning of the visual field. Mean size is computed indirectly by comparing total activity in the input layer and in the third layer. Therefore, information about size of individual elements is lost. Extended model is able to hold statistical information in working memory and to handle computation of mean size for circles also. The model employs several biophysically realistic mechanisms such as gradient synaptic weights, dendritic multiplication and presynaptic inhibition by glutamate spill-over.

# Combining synaptic and cellular resonance in a feed-forward neuronal network

Jonathan Drover Vahid Tohidi Amitabha Bose Farzan Nadim Tuesday Poster – T88

New Jersey Institute of Technology, Newark, New Jersey, US

drover@njit.edu vtohidi@andromeda.rutgers.edu

We derive a mathematical theory to explain the subthreshold resonance response of a neuron to synaptic input. The theory shows how a neuron combines information from its intrinsic resonsant properties with those of the synapse to determine the neuron's generalized resonance response. Our results show that the maximal response of a post-synaptic neuron can lie between the preferred intrinsic frequency of the neuron and the synaptic resonance frequency. We compare our theoretical results to parallel findings on experiments of the crab stomatogastric ganglion.

se is understood at a low enough level for computational modelling. They regulate plasma volume and osmolarity by secreting Arginine Vasopressin (AVP) into the bloodstream to instruct the kidneys to retain water. They are therefore crucial in maintaining plasma osmolarity and volume to within a physiological tolerable range of around 3% during conditions such as dehydration, haemorrhage and salt intake. AVP release is linearly proportional to plasma osmolarity. The neurons are known to fire phasically, particularly under hyperosmotic conditions. A phasic firing pattern is the most efficient to stimulate release at the axon ending, by exploiting a facilitation effect without overly triggering depletion. We present a model to mimic the phasic firing patterns of these neurons. We have also developed a model of axonal release, which we linked to the firing model to produce a secreting cell model. We replicated this and randomised parameters to produce a population distributed over the physiological range. Cells in the population are independent ñ they receive independent inputs and are unconnected. We demonstrate the combination response of this population shows the key features of release during osmotic pressure: a linear increase in firing rate and in secretion. Vasopressin cells are also known to release vasopressin dendritically, which then diffuses round the extracellular space. It acts as feedback to neighbouring cells as well as the originating cell. The model population's performance can be evaluated by how well it sustains release under osmotic pressure: this creates the possibility of creating a framework to quantify theories in terms of computational effectiveness.

# Is receptive field plasticity after a stroke-like lesion optimized for the preservation of topograph

Hildur Einarsdóttir Simon R Schultz Tuesday Poster – T86

MSc Student, London, UK

hildur@imperial.ac.uk simonrschultz@mac.com

In the present study the mechanisms by which the brain attempts to reorganise its information-processing functionality in response to focal ischemia are investigated. Our model simulates the responses of neurons in an area of cortex to sensory stimuli applied within their receptive fields. Plasticity of the cortex is dependent on distance from the lesion and GABA inhibition levels which in turn control the dynamic properties of the receptive fields (RFs). Using the reverse correlation approach, the adaptation of the RFs in neurons surrounding the lesion can be studied over a period of time. The model cells exhibit enlarged RFs, depending on their distance from the lesion, taking up part of the information processing roles of the damaged neurons. By determining how different parameters contribute to these changes, the effect of their values on recovery of the cortex can be assessed. It is our hypothesis that regions of tissue surrounding a focal lesion with low plasticity are only able to take up a fraction, if any, of the roles of the damaged cells and the informational loss due to the lesion will be immense. However, if the surrounding regions are more plastic, they should exhibit enlarged receptive fields that for some value of plasticity would be of the optimum size to make up for as much of the functional impairment present as possible, and optimize the mutual information between stimulus and response. As the plasticity of regions is increased beyond this optimal point their receptive fields should continue to expand up to a certain saturation value which would result in less functionally specific cells, and therefore less exclusive responses that would in turn lower the mutual information again.

Dendritic Morphology Influences Burst Firing         Sunday Poster -S33	A model of intention understanding based on learned chains of motor acts in the parietal lobe
Ronald Elburg	
Arjen vanOoyen	Wolfram Erlhagen Sunday Poster – S69
	Fabian Chersi, Albert Mukovskiy, Leonardo Fogassi, Pier Francesco Ferrari
Experimental Neurophysiology, Vrije Universiteit Amsterdam	Dep. of Mathematics for S&T, Univ. of Minho, Guimaraes, Portugal
Amsterdam, Netherlands	wolfram.erlhagen@mct.uminho.pt, chersi@rocketmail.com
onald@cncr.vu.nl	The understanding of other individualsí actions is a fundamental cognitive
arjen.van.ooyen@falw.vu.nl	capacity for all species living in social groups. It is generally accepted that the mirror circuit is essentially involved in this capacity. Recently we have shown
Burst firing, i.e., the occurrence of clusters of spikes with short interspike	that mirror neurons in the monkey's inferior parietal lobule (IPL, areas PF/PFG),
ntervals, is a specific and important mode of neuronal signaling. Bursts can	while coding a specific motor act like grasping an object, show markedly
mprove the signal-to-noise ratio of neuronal responses, while the fine structure	different activation patterns depending upon the final goal of the action

of bursts may convey stimulus related information and can influence short- and long-term synaptic plasticity. Given the importance of bursts, it is crucial to understand how bursts are generated and what factors influence their occurrence and fine structure. Here we study in a systematic way how dendritic morphology influences the cell's propensity for burst firing. We distinguish between the effects of dendritic topology and dendritic length, and use both somatic and dendritic stimulation. We show that both the total length of the dendritic tree and its topology markedly influence the degree of bursting. Both under somatic and dendritic stimulation, burst firing can occur only for a particular range of tree lengths. Interestingly, this range depends on topology: asymmetric trees start and stop bursting at a lower total dendritic length than symmetric trees. This implies that a small change in the topology of a dendritic tree can change the firing pattern from bursting to non-bursting or vice versa.

### Parallel and Distributed Simulation of Large Biological Neural Networks with NEST

Sunday Poster -S48

Jochen Eppler
Abigail Morrison
Markus Diesmann
Hans Plesser
Marc-Oliver Gewaltig

Honda Research Institute Europe GmbH Computational Neurophysics, Biology III, Offenbach, Germany

eppler@biologie.uni-freiburg.de abigail@biologie.uni-freiburg.de

The Neural Simulation Tool NEST is a simulation environment for large heterogeneous networks of point neurons or neurons with a small number of compartments. In this contribution, we describe two major developments: first, the combination of parallel and distributed simulation. Second, the introduction of a more flexible connection and communication framework. In a companion contribution, we present the main features of NEST from a user's perspective (Gewaltig et al., this volume) In order to combine multi-threaded and distributed simulation, we introduce a new network representation in NEST: in this scheme, the network is represented as list of nodes, which are either neuron models, devices or sub-networks. Device nodes are created for each thread on each computer in order to allow parallel data access and avoid bottlenecks during simulation. Neuron nodes are only instantiated on a single thread to achieve a distribution of the load across all computers. On all other threads a light-weight proxy node is created as representative and serves as a local anchor for a connection which would otherwise join neurons on two separate threads. In this way, from the perspective of an individual thread, all connections appear to be local, thus minimising cache problems. We also implemented a new connection framework which extends the scope of the simulation tool. In the new system, the connection information is stored separately from the nodes. This permits parallel event delivery on multi-processor computers. An A -> B connection in the new system is realized on the unique computer on which neuron B is instantiated; on all the other computers, where B is represented by a proxy node, the connection is ignored. Thus the distribution of the nodes leads to a distribution of the connection information in a natural way. The new connection framework can incorporate plasticity and the usage of heterogeneous synapse types to build a much wider range of networks. Preliminary results indicate that linear scaling of the simulation time with respect to the number of processors can be achieved.

# Contour detection from quasi-ideal contour integration

during the process of action recognition.

sequence in which the act is embedded (placing vs. eating). The experimental

data supports the hypothesis that neurons in the parietal cortex are organized in

dynamic field model which aims at substantiating the idea that the mechanism

for understanding intention may be based on an activation of specific motor

chains in IPL. In its architecture, the model reflects the basic functionality of

anatomically connected populations of neurons in the STS-PF/PFG-F5 mirror

neurons represent motor acts like reaching, grasping or placing by means of self-

stabilized, transient activity patterns. The various subpopulations are coupled via

circuit and the prefrontal cortex (PFC). In the IPL layer, specific pools of

synaptic links, thus establishing a chain toward a rewarded end state or goal

inputs representing object properties and observed motor acts (provided by STS). To validate the model in an action observation task we chose the grasping-placing paradigm used for the experiments with the monkeys. We

represented in PFC. Important cues for triggering the motor chains are visual

show that the connectivity pattern between the various local pools of neurons

can be established through training using a Hebbian rule, and that the resultant distributed network can exhibit a range of physiologically interesting behaviors

chains of motor acts dedicated to achieve certain action goals. Here we present a

Udo Ernst Monday Poster -M42 Nadja Schinkel, Pawelzik Klaus, Sunita Mandon, Simon Neitzel, Kreiter Andreas U Bremen, Bremen, Germany udo@neuro.uni-bremen.de,nadja@neuro.uni-bremen.de

Psychophysical experiments have shown that humans and macaque monkeys are very good in grouping collinearly aligned contour elements which are embedded in a background of randomly oriented edges. However, the neural mechanisms of this process are still not well understood. During the past years, two main model classes have emerged which claim to explain contour integration in the brain: probabilistic models and standard neural network models. Both classes employ 'association fields' (AFs) which implement the Gestalt rule of good continuation to describe dependencies between edge detectors. In probabilistic models, AFs are interpreted as conditional link probabilities, whereas in neural networks, AFs are interpreted as horizontal interaction weights between neural orientation columns with non-overlapping receptive fields. Besides this similarity, there are several important differences between both model classes: Probabilistic models multiply visual input and input from uni-directional horizontal interactions. In contrast, in standard neural networks all inputs are summed up, and horizontal interactions extend bi-directionally in visual space. The conditional link probabilities or AFs can be used to generate contour ensembles with pre-defined statistical properties by means of a Markov process. Consequently, contours are integrated optimally when using the same AF. While this poses no problem in a probabilistic model, the brain can not readily adapt the structure of horizontal interactions to the statistics of the current stimulus. In order to identify plausible neural mechanisms of contour integration, we investigate the explanatory power of these model classes. In particular, we compare model predictions to human behaviour using identical stimuli in simulations and psychophysical experiments. For this purpose, we implement a novel method for a quantitative comparison between the individual decisions from different contour observers like humans or models. We first find that decisions between humans are systematically correlated, hereby establishing a benchmark for models which should reproduce not only the human performance, but also any systematic errors due to illusory contour configurations. Second, a comparison of different model classes with human observers basing on both, correlations and detection performance, strongly suggests the involvement of multiplicative interactions between neuronal feature detectors in contour integration. Finally, by taking into account the eccentricities of the contour elements, we show that a very good match between multiplicative models and empirical results can be achieved.

Reliability and stochastic synchronization in type I vs. type II neural	
oscillators	

Roberto Fernández-Galán Tuesday Poster – T20 Bard Ermentrout Nathaniel Urban

Carnegie Mellon University, Pittsburgh, Pennsylvania, USA

galan@cnbc.cmu.edu bard@pitt.edu

Neurons respond to several repetitions of a rapidly fluctuating stimulus in a highly reproducible manner. This property has been referred to as neural reliability. The synchronization of an ensemble of neurons by correlated noisy inputs (stochastic synchronization) can be regarded as a generalization of this phenomenon: neurons receiving correlated fast fluctuating signals will demonstrate correlated responses across the ensemble, which translates into partial synchrony of their action potentials. The degree of synchronization depends on the reliability of the neurons in the ensemble and on the degree of spatial correlation of the inputs. But interestingly, stochastic synchronization occurs even when the neurons are not mutually connected. Neural reliability and stochastic synchronization are remarkable features of neurons with relevant consequences for neural computation: Whereas neural reliability is crucial for the high fidelity of sensory processing, stochastic synchronization may provide a general mechanism for binding neural representations of stimuli even across sensory modalities, and therefore for routing information in the brain. We have investigated the mechanisms for neural reliability and stochastic synchronization in experiments with acute brain slices of the olfactory bulb in rodents and also in computer simulations of simple neural models. We concluded that both phenomena are universal properties of neurons, as devices with a resetting threshold. However, further computational studies with phase-oscillator models of neurons revealed that type II neural oscillators (resonators) are more reliable and more susceptible to synchronize by stochastic inputs than are type I neural oscillators (integrators). A heuristic explanation for this remarkable difference is provided, that is based on the shape of the neuronis phase response. Interestingly, in recent experimental studies on the olfactory system, we have shown that mitral cells behave as neural resonators, which suggests that they have evolved to optimize sensory reliability and to quickly synchronize through spatially correlated barrages of inhibitory inputs from granule cells.

#### Dynamics of first spike latency with and without A-type currents: implications for cerebellar Purkinje cell spike firing dynamics

Fernando Fernandez Raymond Turner Tuesday Poster - T59

University of Calgary, Calgary, Canada

ffernand@ucalgary.ca rwturner@ucalgary.ca

Inactivating potassium currents, termed iA-typeî (IA), have been proposed to play a critical role in permitting low frequency spike firing and setting first spike latency. Dynamical systems analysis, however, shows that low frequency firing can be generated by simple biophysical models in the absence of IA. In fact, these dynamics arise in models that have a non-monotonic current-voltage (I-V) relationship. We show here that IA is also not required for a hyperpolarizationsensitive long first-spike latency behavior normally attributed to IA, but can result from incorporating fast refractory dynamics that produce a specific bifurcation structure. The relative abundance of IA in central neurons, however, suggests that these currents have an important role in controlling spike firing dynamics. We use simulations, dynamical systems analyses and electrophysiological recordings to understand the specific consequences of incorporating IA to neuronal dynamics and the biophysical basis for first spike latency behavior without IA. We show that IA linearizes the first spike latencyvoltage relationship and decreases the susceptibility of the first-spike latency to noise. Current and-voltage clamp recordings from mature rat cerebellar Purkinje cells indicate that they lack IA, yet produce long first-spike latency times that would ordinarily be attributed to inactivating potassium currents. Rather, predictions arising from dynamical analysis of the model without IA are fully reproduced by Purkinje cells, confirming the presence of these dynamics in a major output cell of the CNS.

### Neural response profile design

Monday Poster -- M17

### Erik FransÈn

Royal Institute of Technology, Stockholm, Sweden

#### erikf@nada.kth.se

Neurons obtain their dynamical electrical characteristics by a set of ion channels. These properties may not only affect the function of the neuron and the local network it forms part of, but it may also eventually affect behavior. For instance, a mutation of a gene coding for a chloride channel can lead to epilepsy (Haug et al., Nat Genet, 2003). We were interested to study whether the opposite could be achieved, reducing epileptogenic activity by adding a channel. In this project, we are using computational techniques to optimize ion channel properties for the goal of modifying neural response characteristics. We strive to reduce neural responses to highly synchronized inputs while leaving inputs of other degrees of synchronicity unaffected. Our results show that this type of parameter search is possible and reasonably efficient. We also show that it is possible to change a neuron's characteristics selectively with regard to response to degree of synchronicity.

### Slowness leads to Place Cells

Tuesday Poster – T5

Mathias Franzius Henning Sprekeler Laurenz Wiskott

Humboldt Univerity Berlin, Institute for Theoretical Biology Berlin, Germany

m.franzius@biologie.hu-berlin.de h.sprekeler@biologie.hu-berlin.de

We present a model for the self-organized formation of hippocampal place cells based on unsupervised learning on natural visual stimuli. Our model consists of a hierarchy of Slow Feature Analysis (SFA) modules, which were recently shown to be a good model for the early visual system. The system extracts a distributed representation of position, which is transcoded into a place field representation by sparse coding (ICA). We introduce a mathematical framework for determining the solutions of SFA, which accurately predicts the distributed representation of computer simulations. The architecture of the largely parameter-free model is inspired by the hierarchical organization of cortex. Our studies show that the model is capable of extracting cognitive information such as an animal's position from its complex visual perception, while becoming completely invariant to the animal's orientation.

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the likely substrate for this matching process. For example, Eph-A receptors are expressed in a decreasing gradient along the naso-temporal axis of the retina while their ephrin A ligands increase along the caudal-rostral axis of the tectum. In principle this allows a retinal axon to be targetted to a particular termination zone within the tectum. There are several plausible mechanisms for how this targetting might occur. These models are able to account to varying degrees for recent key findings, but do not address a number of experiments carried out even before the discovery of Eph-ephrin signalling. The experiments involved recovery of the topographic projection following ablation of portions of the retina or tectum, in which the resulting mapping is seem to expand or contract appropriately, apparently making optimal use of the remaining areas. This paper describes a model for the formation of topographic mappings that incorporates the recent discoveries about Eph-ephrin signalling and is able to account for the expansion and contraction experiments. The model features (a) regulation of ephrin expression in cells that are innervated from the retina, with changes acting to match the current ephrin value to a target level, and (b) smoothing of ephrin levels in the tectum via a local diffusion process. It also incorporates a continuous tectum and `soft' competition between RGC axons for tectal space, as well as a tendency - rather than a hard constraint - for those axons to terminate in the tectum. An appealing feature is that since the ephrin levels are being reset, an axon growing from the retina at a later time should still find the correct position in the tectum.

## Roles of short-term synaptic plasticity in electrosensory perception under competing sensory signals

Kazuhisa Fujita Yoshiki Kashimori Tuesday Poster – T87

University of Electro-Communications, Chofu, Japan <u>k-z@nerve.pc.uec.ac.jp</u>, kashi@pc.uec.ac.jp

Short-term synaptic plasticity is ubiquitous in sensory systems. There has been significant progress in understanding the mechanism underlying short-term synaptic plasticity. However, the functional roles of plasticity in sensory coding and behavior are not well understood. To investigate this issue, we studied the functional roles of short-term synaptic plasticity in electrosensory perception under competing signals of electrolocation and communication. Weakly electric fish use amplitude modulations of their self-generated electric organ discharge (EOD) to detect object nearby the fish and communication signals from a neighboring fish. The electric fish receives simultaneously two kinds of EOD amplitude modulations (EOD AMs), each of which is elicited by an object or a neighboring fish. The EOD AM elicited by an object is spatially localized around the object and has a low temporal-frequency ( < 10 Hz), whereas the EOD AM elicited by a neighboring fish is globally distributed over the fish body surface and has a high temporal-frequency ( > 20 Hz). The former is used for electrolocation and the latter for electrocommunication. The fish must extract in hindbrain the sensory features relevant to the behavior and then bind them in midbrain, in order to know the situation of environment. To extract successfully the sensory information in the hindbrain and the midbrain, the neural activities needs to be modulated by short-term synaptic plasticity. The roles of short-term synaptic plasticity in the hindbrain and the midbrain have been reported at single cell level. However, it is not yet clear how the short-term synaptic plasticity is used in the hindbrain and midbrain networks to extract and bind the stimulus features relevant to the two types of behavior. We developed a model of fish body by which we calculate numerically the spatiotemporal patterns of electric field around the fish body, and made a model of electrosensory system which consists of receptors, hindbrain, and midbrain. We show here that the short-term synapses of hindbrain neurons are used to extract efficiently the spatiotemporal features required for electrolocation and communication from the competing signals. We also show that the short-term synapses of midbrain neurons are needed to combine consistently the two different stimulus features of the two types of behavior.

#### to-one mapping between a stimulus and a motor response. Every event or action can modify the animal disposition to behavior, and, for example, the same sensory stimulus might lead to different motor responses depending on the context, previously determined by a set of other cues. We propose a network model in which each inner mental state is represented by an attractor of the neural dynamics. Each state represents a rule encoding the prescriptions for going from one state to another or for expressing a decision about a motor response. We illustrate this theoretical framework with a simple example. We consider a task in which an animal has to respond with a saccadic movement (Left or Right) to two sensory stimuli (A and B). In one context A should lead to L and B to R. In another one the associations are reversed and A should lead to R and B to L. The two rules can be expressed in words as: 1) when A is associated with L, then B is associated with R 2) if A leads to R, then B leads to L. We address two issues: how are the rule representations built? How can the active representation of a rule lead to the decision about the motor response? We propose a network in which two populations of neurons compete to express a final decision about the motor response (L or R). These two populations are assumed to be highly structured due to heterogeneities. In particular we assume that within L there is a population AL which has a preference for A (i.e. before learning, A drives it to higher frequencies than other neurons within L). Analogously we can define populations BL, AR, BR. When the first rule (AL-BR) is in effect, the activation of AL is consistently followed by the activation of AL or BR. The rule representation then forms because of the temporal contiguity of AL-BR for rule 1, and AR-BL for rule 2. When rule 1 is active, then A favors L in the competition because AL receives a recurrent (from BR) and a sensory input, while BR receives only the recurrent input. Hence stimulus A steers the activity of the network towards a state which expresses the final decision about the motor response and it keeps in memory which rule is in effect

# NeuronRank for Mining Structure-Activity Relationships of Biological Neural Networks

Tayfun Gürel Luc De Raedt Stefan Rotter Tuesday Poster -T41

Bernstein Center for Comp. Neuro., Freiburg Machine Learning Lab., University of Freiburg, Freiburg, Germany

guerel@informatik.uni-freiburg.de deraedt@informatik.uni-freiburg.de

It is a difficult task to relate the structure of a cortical neural network to its dynamic activity analytically. In the present work, we employ machine learning and data mining algorithms to obtain these relations from example random recurrent cortical networks and corresponding simulations. Inspired by the Page-Rank and Hubs & Authorities, we introduce the NeuronRank algorithm, which assigns a source value and a sink value to each neuron in the network. We show its usage to extract features from a network for a successful prediction of its activity. Our results show that NeuronRank features are successful to predict average firing rates in the network, and the firing rate of output neurons reading the network.

#### A neuronal model of the language cortex

Sunday Poster - S93

Max Garagnani, Thomas Wennekers, Friedemann Pulverm, ller MRC-Cognition&Brain Sciences Unit, University of Cambridge, UK <u>max.garagnani@mrc-cbu.cam.ac.uk</u>, thomas.wennekers@plymouth.ac.uk

During speech production, two different areas of the brain become simultaneously active: primary motor cortex (responsible for sound articulation) and auditory cortex (stimulated by the produced sounds). We postulate that during language acquisition, the repeated simultaneous activation of these two areas leads, through Hebbian learning, to the formation of strongly-associated cell assemblies, which are: (a) distributed across cortical areas, (b) wordspecific, and (c) activated even by only partial (e.g., auditory) stimulation. In order to test the validity of this hypothesis, we: (1) simulated learning of neural assemblies in a biologically-motivated computational model of the left perisylvian language cortex; (2) observed the functional characteristics of the resulting model, and (3) explored its neurophysiological properties and compared them with real experimental data. Six cortical areas were simulated: (i) primary auditory cortex, (ii) auditory belt and (iii) parabelt areas (Wernicke areas), (iv) inferior prefrontal and (v) premotor cortex (Broca areas), and (vi) primary motor cortex. Each area (layer) consisted of a 25x25 grid of gradedresponse neurons. The network included random recurrent, forward and backward links; recurrent connection probabilities decreased with increasing cortical distance following a Gaussian distribution; between-area links were topographic and followed the same probability distribution; non-adjacent layers had no connections. Local and global inhibition mechanisms controlled activity within each layer. The model was confronted with simultaneous patterns of activations in both its auditory (1) and motor (6) layers, as one would expect it in early speech production. During training, the synaptic weights of all excitatory links were modified according to the co-variance learning rule [Sejnowski, 1977]. We observed formation of cell assemblies, different assemblies responding selectively to different input patterns. We also observed the presence of spontaneous rhythmic activity in the network. During the testing phase, the following functional characteristics emerged: when only the auditory layer was stimulated with one of the learnt patterns (words), we observed that (a) the relevant assembly was immediately and strongly activated in that layer and started to oscillate: (b) the rhythmic activity of the assembly in that layer spread to the remaining layers; (c) presentation of new, previously unseen ipseudo-patternsî (pseudo-words) produced, on average, a smaller response in the network than that produced by words. These results are consistent with recent evidence obtained from EEG recordings of the brain activity during speech-listening tasks, and help explain neurophysiological observations about cortical processing of words and pseudowords in terms of a clearly-defined neurobiological model of language

### The Neuroinformatics Digital Video Toolkit (NIDVTK)

Esther Gardner, Eric J. Lang, Adam Sherwood gardne01@med.nyu.edu, lange01@med.nyu.edu

Tuesday Poster – T68

Digital video provides a convenient modality for integrating neurophysiological and behavioral analyses of complex motor actions. We demonstrate a suite of neuroinformatics data analysis tools (NIDVTK) for correlating skilled hand movements imaged in digital video with synchronized spike trains recorded by multiple-electrode arrays. The toolkit implements procedures for importing AIFF files of spike trains, spike sorting, construction of rasters, PSTHs, and burst analysis graphs linked to behaviors. We use recordings from posterior parietal cortex to illustrate use of these tools. Digital video images of hand kinematics synchronized to neuronal spike trains were recorded in posterior parietal cortical (PPC) areas 5 and 7b/AIP of three monkeys. They were trained in a prehension task to grasp and lift rectangular blocks, and large and small spheres using a whole hand, power grasp posture. Hand actions were correlated to neuronal firing patterns using video time code to link rasters and PSTHs to the onset of reach, hand contact, grasp and lift of the objects. PPC neurons responded most vigorously to object acquisition, but not manipulation. Firing rates rose 200-500 ms before touch, and peaked as the hand was preshaped during reach, or at contact. They declined as grasp was secured, and returned to baseline or were inhibited during lift, hold, and lower actions. The onset of firing in PPC paralleled that in motor cortex of the same animals, but preceded activity in SI cortex that began at contact and peaked during grasp. PPC firing rates were better correlated to the hand postures used to acquire specific objects than to their size, shape or location. Our findings support the hypothesis that PPC activity reflects subjective intentions to accomplish task goals. It also provides sensory signals from self-generated behaviors that confirm or refute expectations inherent to such actions. This Human Brain Project/Neuro Informatics research is supported by Research Grant NS44820 funded jointly by NINDS, NIA and NIMH, and by Research Grant NS11862 from NINDS.

### Neural Control and Synaptic Plasticity in a Planar Biped Walking Robot

Tao Geng Tomas Kulvicius Bernd Porr Florentin Woergoetter

University of Stirling, Stirling, UK

tgeng@cn.stir.ac.uk tomas@chaos.gwdg.de

Biped walking remains a difficult problem and robot models can greatly facilitate our understanding of the underlying biomechanical principles as well as their neuronal control. The goal of this study is to specifically demonstrate that stable biped walking can be achieved by combining the physical properties of the walking robot with a small, reflex based neuronal network, which is governed mainly by local sensor signals. Here we will show that human-like gaits emerge without specific position or trajectory control and that the walker is able to compensate small disturbances through its own dynamical properties. The reflexive controller used here has the following characteristics, which are different from earlier approaches: (1) Control is mainly local. Hence, it uses only two signals (AEA=Anterior Extreme Angle and GC=Ground Contact) which operate at the inter-joint level. All other signals operate only at single joints. (2) Neither position control nor trajectory tracking control is used. Instead, the approximate nature of the local reflexes on each joint allows the robot mechanics itself (e.g., its passive dynamics) to contribute substantially to the overall gait trajectory computation. (3) Adaptive control can be achieved by an implemented synaptic plasticity mechanisms related to spike timingdependent plasticity. As a consequence, this robot system closely couples adaptive neural control with an appropriate biomechanical design leading to dynamically stable biped walking gaits which can change during netowrk learning. This is demonstrated by different walking experiments using a real robot as well as by a Poincare map analysis applied on a model of the robot in order to assess its stability.

# Exploring large-scale models of neural systems with the Neural Simulation Tool NEST

Marc-Oliver Gewaltig Markus Diesmann

Sunday Poster -S49

Sunday Poster - S57

Honda Research Institute Europe GmbH Offenbach, Germany

marc-oliver.gewaltig@honda-ri.de diesmann@biologie.uni-freiburg.de

The Neural Simulation Tool NEST is a simulation environment for large heterogeneous networks of point neurons or neurons with a small number of compartments. In this contribution, we present the main features of NEST from a user's perspective. Through a number of examples, we illustrate how largescale simulations of neural systems can be constructed and executed. We also present results which demonstrate the capabilities and performance of NEST in large-scale simulations, using multiple processors or cores. In a companion contribution, we describe our latest technological advances in integrating parallel and distributed simulation (Eppler et al.) A network simulation in NEST is set up in a number of steps: First, a network model is constructed by creating neurons from a set of different models and connecting them in the desired way. It is possible to combine model neurons of different types, thereby constructing heterogeneous networks. Sub-networks help to hierarchically organize large networks. A simulation follows the analogy of an electrophysiological experiment. Measurement and stimulation of network dynamics are made possible by special network elements, called devices. After the network is set-up, it can be executed for a given amount of time, and results may be analyzed either online or offline. A powerful and flexible simulation language supports the user in tasks which require the combination of simulation and data analysis such as scanning the parameter space of a model, or interfacing with packages like Matlab, Mathematica, or Python, for online analysis or visualization. Moreover, the modularized and extensible architecture allows NEST to be tailored to a wide range of applications. NEST is developed and maintained by the NEST Initiative (see www.nest-initiative.org), which also provides public releases under an open-source type license. Our current research focuses on the integration of parallel and distributed simulation strategies into a common framework (Morrison et al. 2005, Neural Computation).

A computational model relating changes in cerebral blood volume to synaptic activity in neurons		A Synfire Chain Model of Zebra Finch Song	
		Christopher Glaze	Tuesday Poster – T25
William Gibson	Monday Poster –M26	Todd Troyer	
Les Farnell			
Bennett Max		Program in Neuroscience and Cognitive Science, University of Maryland,	
		College Park, College Park, Marylan	id, USA
University of Sydney, Sydney, Australia		cmglaze@gmail.com, ttroyer@glue.umd.edu	
billg@maths.usyd.edu.au		Many complex sequential behaviors have been demonstrated to have a	
lesf@maths.usyd.edu.au		hierarchical organization both behav	iorally and in the nervous system. Zebra

The assumption that there is a tight coupling between neuronal activity and blood flow and oxygenation underlies the interpretation of brain images produced by modern non-invasive techniques, particularly fMRI (functional Magnetic Resonance Imaging). However, there is only an indirect, and at present incompletely understood, relation between what is seen on the screen and what is happening at the neuronal level, since fMRI detects changes in blood flow and oxygenation in cerebral blood vessels, and not electrical activity in neurons. There must be some mechanism for information to pass from a neuron to the neighbouring capillaries and arterioles supplying the blood and it is now becoming increasingly clear that the key element in this signalling process is the astrocyte (a type of glial cell that actually outnumbers neurons in the brain.) We have constructed a model of the steps leading from neural activity to increased blood flow in arterioles. Glutamate released from neuronal synapses binds to metabotropic receptors on the astrocyte processes that ensheath these synapses. This initiates a calcium wave that travels along the endfeet of astrocytes that abut the endothelial cells forming the walls of blood capillaries; this calcium wave is propagated by the extracellular diffusion of ATP (adenosine triphosphate) that acts on metabotropic purinergic receptors on the astrocytes. A further second messenger (nitric oxide or adenosine) relays this signal to the smooth muscle cells forming the outer walls of arterioles, and the subsequent wave of hyperpolarization reduces calcium influx and allows relaxation of the muscle cells and hence increased blood flow. The model gives results that are in agreement with experimental measurements of blood volume changes in the arterioles in the visual cortex of visually stimulated cats.

#### Bursting and global oscillations in networks of adapting spiking neurons

Guido Gigante Paolo DelGiudice Maurizio Mattia Tuesday Poster –T35

University of Rome, Istituto Superiore di Sanit, Rome, Italy

guido.gigante@iss.infn.it paolo.delgiudice@iss.infn.it

The population bursting and global oscillatory activity is studied in a network of spiking neurons with spike frequency adaptation driven by the modulation of an inhibitory current dependent on the calcium concentration. Using a population density approach, the dynamical properties of the system are studied and its phase space is shown. A possible link with in vitro experiments is suggested.

hierarchical organization both behaviorally and in the nervous system. Zebra finch songs consist of highly stereotyped sequences of vocalizations (syllables), making them especially well suited for in depth analysis of this kind of organization. The song code is known to involve premotor nucleus HVC and downstream projections, although there are conflicting data on whether syllables have discrete representations separate from global song structure. On the one hand, there is physiological evidence that HVC is a clock-like mechanism that drives song without distinguishing syllables from the silent gaps between them (Hahnloser et al., 2002). On the other hand, we recently found that song acoustics have two independent sources of temporal variance that distinguish syllables from gaps on the msec-time scale (Glaze and Troyer, 2006). Specifically, syllables stretch and compress with tempo changes proportionally less than gaps (they are less ``elastic"), while, after factoring out tempo, syllable-syllable and gap-gap length correlations are significantly stronger than syllable-gap correlations. In this research we have modeled song production using synfire chain models consisting of conductance-based point neurons. We induced tempo changes with variations in tonic excitation across neurons, and find that elasticity differences can be had by making the synaptic connections subserving syllables stronger than those for gaps. We also used two basic methods for producing the correlation patterns. First, we consider two different 'chunked" models, in which chains corresponding to syllables and gaps receive differing sources of tonic input. Second, we find that the introduction of inhibitory feedback and song-to-song variations in inhibitory gain can also produce the correlation patterns seen in our behavior data, as long as (1) gain varies independently of tonic excitation and (2) changes in inhibitory gain have a different relative effect on syllable and gap lengths than does changes in tonic excitation. Finally, we find that the addition of synaptic noise does not significantly alter temporal structure, although it does bias longer chains to correlate with each other more strongly than shorter chains. In general, we have used reduced models and simple linear equations to provide computational links between measured temporal structure in a complex behavior and what could be expected from synfire chain models of premotor pattern generators.

NeuroConstruct: a software tool for constructing biologically realistic neural network models in 3D

Padraig Gleeson	Sunday Poster –S38
Volker Steuber, R. Angus Silver	

Department of Physiology, UCL, London, UK p.gleeson@ucl.ac.uk, v.steuber@ucl.ac.uk

The 3D structure and interconnectivity of many brain regions (e.g. the cerebellum) is believed to be an essential determinant of their behaviour. To effectively model such networks and to compare the population behaviour with experimental measurements, it is important to create model networks in 3D. The models should incorporate the neuronsí complex dendritic structures with realistic channel distributions, where much of the information processing is believed to occur, and also reproduce the anatomically determined connectivity. A software application, neuroConstruct, has been developed which facilitates the development of such networks in 3D. Cell models can be created based on imported neuronal morphology files, e.g. Neurolucida, and appropriate channel and synaptic mechanisms can be added. Cells can be positioned in 3D to mimic the observed arrangement in tissue samples. Connections between cells can be generated and the network structure analysed. The application can generate code for execution in either NEURON or GENESIS and the network behaviour can be visualised and analysed with neuroConstruct. The software uses a number of emerging standards to ensure simulator independence of the models. MorphML is a standard for specifying anatomical details of neurons in XML. This has been recently extended to incorporate biophysical properties of cells, to enable a complete description of biologically realistic cells. A standard for specifying the behaviour of channel and synaptic mechanisms has also been developed. ChannelML allows a descriptive (as opposed to procedural) description of the voltage and/or concentration dependent ion channels, synaptic mechanisms and internal ionic concentrations. These standards facilitate generation of NEURON and GENESIS scripts for the mechanisms in neuroConstruct, as well as translation between systems of units (e.g. SI or physiological). One of the main goals of the application, besides facilitating the development of 3D networks with complex connectivity, is making neuronal models more open to the wider neuroscience community, especially experimentalists. The 3D visualisation capability and the point and click interface facilitate editing of the cellular morphologies, channel mechanisms, connectivity patterns and simulation settings without the need to learn a simulator specific scripting language. Numerous automated checks help to eliminate common mistakes and incorrect settings which may lead to erroneous simulation results. The power and flexibility of the target simulation environments is not lost however, with the ability to have native scripts run at various points during the simulation. This work has been funded by the MRC and the Wellcome Trust.

#### Using Extracellular Action Potential Recordings To Constrain Compartmental Models

Monday Poster – M8

California Insitute of Technology Pasadena, California, USA

carlg@caltech.edu koch@klab.caltech.edu

Carl Gold

Christof Koch

We compare two different methods for constraining the active current conductance density parameters of detailed compartmental models. The first method is using measurements of the intracellular action potential (IAP) at one or more locations on the membrane. The second method is to calculate the Extracellular Action Potential (EAP) from the membrane currents, using the Line Source Approximation (LSA). We find that the IAP method underconstrains the parameters. As a result, significantly different sets of parameters can have virtually identical IAP's. In contrast, the EAP method results in a much tighter constraint. The EAP's change considerably as a result of much more modest parameter differences. The reason for this phenomena is that the IAP results from both membrane currents on a compartment and also axial current flowing from neighboring compartments. The EAP results from the local membrane currents alone. This gives the IAP additional degrees of freedom in comparison to the IAP. Based on these results we conclude that EAP recordings are an excellent source of data for the purpose of constraining compartmental models

# Computational Neuroinformatics: Toward Distributed Neuroscience Data Discovery

Sunday Poster -S44

David Goldberg Jonathan Victor Esther Gardner Daniel Gardner

Department of Physiology & Biophysics, Weill Medical College of Cornell University, New York, New York, USA

dhg2002@med.cornell.edu jdvicto@med.cornell.edu

Toward a computational neuroinformatic resource for the sharing and analysis of neurophysiology data, we are enhancing the data repository at Neurodatabase.org with a suite of complementary methods for information theoretic spike train analysis. The goal of the project is to make both data and analytical techniques available to the neuroscience community and to catalyze collaborations between experimenters and theoreticians. To this end, we invite computational neuroscientists to work with us to incorporate innovative analysis techniques in the resource. We further invite experimental neuroscientists to contribute a broad range of neurophysiological recordings. We report availability of the analysis tools in the first of two planned formats, a Spike Train Analysis Toolkit, available at http://cortex.med.cornell.edu/toolkit. Tools are written in C, can be called as a Matlab toolbox or through an API, and run on Windows, Mac OS, and Linux. The Toolkit currently includes three methods for estimating mutual information: the direct method (Strong et al., 1998), the metric space method (Victor & Purpura, 1997), and the binless embedding method (Victor, 2002). Several entropy bias and variance estimation techniques are included. The in-progress adaptation of the Toolkit for use on an internetaccessible parallel computational array will enable computationally intensive analyses, such as those required for populations of multiple simultaneously recorded neurons. To demonstrate the potential for our resources to catalyze collaborations, we analyzed data obtained from Neurodatabase.org with the Spike Train Analysis Toolkit using only information supplied in datasets and metadata. The data consisted of single- and multi-neuron spike trains were obtained from the parietal cortex of macaque monkeys during a prehension task (Debowy et al., 2002). Analysis with the metric space method revealed that neurons simultaneously encoded information about multiple aspects of the task kinematics on varying timescales. Preliminary multi-neuron analysis indicates that the information conveyed by pairs of nearby neurons is largely redundant, and keeping track of the source of the spike does not increase the amount of information conveyed. Supported by Human Brain Project/Neuroinformatics MH68012, MH057153, and NS044820.

#### Abnormal Retinal Waveform in rd /rd mouse Recorded with Multielectrode Array

Yong Sook Goo Jang Hee Ye Je Hoon Seo Tuesday Poster -T54

Dept. Physiology, Chungbuk National Univ. Med, Cheongju, South Korea

ysgoo@chungbuk.ac.kr tim1981@chungbuk.ac.kr

We investigated the differences of the retinal spikes in normal and degenerate retina. We used C3H/HeJ strain (rd /rd mouse) as retinal degeneration model. Multielectrode recordings were performed in the isolated retina. In control mouse (C57/BL6J) of 4 weeks old, only short duration (< 2 ms) ganglion cell spikes were recorded. But in rd/rd mouse, besides normal spikes, waveform with long duration (~ 100 ms) were recorded regardless light stimulus.

Towards increased biological plausibility: A reinforcement version of	
Elman back-propagation	

André Grüning	Sunday Poster – S79
SISSA, Triese, Italy	
gruening@sissa.it	

Simple recurrent networks trained with Elman back-propagation (BP) are a commonly used tool in model building in neuro-inspired cognitive science. However it has been claimed that they are not biologically plausible, since not all of their components can be biologically justified. We suggeste a variant of Elman BP which overcomes at least one of the biological short-comings, namely the need for an explicit target in training, simply by adding some reinforcement flavour to Elman BP. This new algorithm is called recurrent back-propagation as reinforcement (RBPREINF), and it can be shown that in theory its learning behaviour still is essentially that of Elman BP, since expected weight changes are the same. In this article we review the new algorithm and present new simulational data that confirms the match of learning behaviours. We also discuss briefly the biological plausibility of components that enter in RBPREINF.

# Excitary and Inhibtory Synaptic Inputs are Modulated Through The Spatial Distribution of Dendrititic Voltage-Dependent Channels

Gideon Gradwohl Yoram Grossman Monday Poster - M27

Dep. of Software Engineering, College of Enginnering, Beer-Sheva, Israel gidi.gradwohl@gmail.com, ramig@bgu.ac.il

We simulated a reconstructed alpha-motoneuron by using realistic physiological and morphological parameters. In our simulations, we examined two distribution functions of the voltage dependent sodium and potassium channels on the dendrites: 1.) Exponential decay (ED), illustrated by a high conductance density located proximal to the soma, exponentially decaying away from the soma; 1.) Exponential rise (ER), where the proximal low conductance density increases exponentially with the distance. We kept the total action conductance (G, Siemens) constant, allowing us to compare the results from the two models. In all simulations the synaptic inputs were distributed as a Gaussian function on the dendrites. The soma and axon remained passive in order to clear out the dendritic processes. We then tested the resulting EPSP and its inhibition by IPSP under the above conditions and found that the introduction of a dendritic active conductance had prominent effects on the synaptic potentials. Our simulations lead to the following key observations: 1.) The presence of active conductances on the dendrite amplified the EPSPpeak relative to a passive model EPSP. 2.) Dendritic ED dispersion of voltage dependent channels increased EPSPpeak and its inhibition more effectively than in the ER model. 3.) Relative to the passive model potentials, the ED distribution significantly improved EPSPpeak inhibition, while it depressed peak inhibition in the ER model. The data suggested that the specific distribution of the voltage-dependent conductance (channels) in the dendrite, in addition to its magnitude, might affect neuronal synaptic integration.

Spiking Neuron Models based on Midbrain Mechanisms that Guide Visual Behavior

Brett Graham	Monday Poster –M43
David Northmore	

University of Delaware, Newark, Delaware, USA <u>bjgraham@udel.edu</u>, northmor@psych.udel.edu

A model is presented that demonstrates the interaction of two prominent midbrain structures, the optic tectum and nucleus isthmi (NI) which are reciprocally interconnected. The model mimics the known anatomy and visual function of these structures in teleost fishes, using leaky integrate-and-fire spiking neurons. During direct approach to objects, the model tectum estimates (1) retinal image size and (2) its rate of expansion. These are converged onto a model NI to extract object proximity. The NI signal is fed back to scale image size, thereby estimating object size. The tectum-NI model controls a simulated animat moving at a constant speed in an environment with various sizes of spherical stimulus objects. Using only monocular visual cues, the model consistently discriminates spheres on the basis of their diameter. It approaches and contacts spheres smaller than a critical diameter while avoiding larger ones. The results provide insight into how these midbrain structures interact to process the visual scene.

# Transitions in a bistable model of the ${\rm Ca}(2+)/{\rm calmodulin-dependent}$ protein kinase-phosphatase system

Michael Graupner Nicolas Brunel Monday Poster – M33

Laboratoire de Neurophysique et Physiologie UniversitÈ RenÈ Descartes - Paris 5, Paris Cedex 06, France

michael.graupner@univ-paris5.fr, nicolas.brunel@univ-paris5.fr

The calcium/calmodulin-dependent protein kinase II (CaMKII) plays a key role in the induction of long-term post-synaptic modifications following calcium entry in the postsynaptic cell. Experiments suggest that long-term synaptic changes are all-or none switch-like events. The biochemical network involving CaMKII and its regulating protein signaling cascade has been hypothesized to be a bistable realization of such a switch. However, it is still unclear whether LTP/LTD protocols lead to transitions between the two states in realistic models of such a network. A detailed biochemical model of the CaMKII autophosphorylation and the protein signaling cascade governing the CaMKII dephosphorylation is presented. Dephosphorylation is mediated by protein phosphatase 1 whose activity is indirectly regulated by the calmodulin/calciumdependent balance between protein kinase A (PKA) and calcineurin. All of these proteins are known to be involved in synaptic plasticity and the implemented interactions are experimentally supported. To investigate how the model behaves when realistic calcium transients are applied to it, we use a minimal model to describe postsynaptic calcium and postsynaptic voltage dynamics. To furthermore examine stochastic effects, we add possible sources of noise to the model. As reported by Zhabotinsky [Biophys J 2000 Nov; 79:2211-21], two stable states of the system exist at resting intracellular calcium concentration: a weakly-phosphorylated (DOWN) and a highly-phosphorylated (UP) state of the CaMKII. A transition from the DOWN to the UP state can be achieved by high calcium elevations, with an UP-shifting threshold which is determined by the competing CaMKII autophosphorylation and dephosphorylation dynamics. In addition, intermediate calcium concentrations enhance CaMKII dephosphorylation due to a relative increase in calcineurin activity while the PKA activity remains relatively low in this range. This results in depotentiation switching from the UP to the DOWN state - during respective calcium transients. The transitions in both directions, from the DOWN to the UP state and vice versa, are achieved in response to calcium levels which resemble those which are present during LTP and LTD induction protocols. It is shown that the CaMKII system can qualitatively reproduce results of plasticity outcomes in response to experimental induction paradigms of long-term modifications. Finally, the impact of stochastic fluctuations on the results of plasticity outcomes of the CaMKII system will be discussed.

#### Stability Constraints on Networks of Brain Components

Richard Gray Peter Robinson Candy Fung School of Physics, Camperdown, Australia r.gray@physics.usyd.edu.au robinson@physics.usyd.edu.au

Tuesday Poster – T56

Recent analysis of experimentally determined cortical connection networks has shown they have many characteristic properties shared across neural systems and species with the small world attributes of high clustering and short path lengths. The biological reasons for this network structure in the brain have yet to be determined. Our approach is to investigate the dynamics and stability of networks of brain components using a physiologically based continuum model of brain electrical activity. If instabilities correspond to neurological disorders such as seizures. stability will be an important constraint on network structure and, hence, brain physiology and anatomy. An excitatory random network is shown to be almost surely stable if npg < 1, where nis the number of components, p the probability of connection, and g the connection gain. Investigations into the stability of small world networks and the change in stability characteristics as a network crosses over from a small world to a random structure are also presented. Implications of these results for brain structure and its evolution are made, along with comparisons to connection networks of the visual cortex.

A single neuronal network model of familiarity and recollection based recognition memory		Aging and Reward Modulation of the Episodic Memory Circuitry: A Neurocomputational Inquiry	
Andrea Greve	Sunday Poster – S99	Dorothea Haemmerer	Sunday Poster –S102
Mark van Rossum		Shu-Chen Li	
David I. Donaldson		Timo von Oertzen	
		Ulman Lindenberger	
University of Edinburgh, Edinburgh, UK			
		Max Planck Institute for Human Development, Berlin, Germany	
a.greve@sms.ed.ac.uk		haemmerer@mpib-berlin.mpg.de, shuchen@mpib-berlin.mpg.de	
mvanross@inf.ed.ac.uk			
		Successful episodic memory operation	s involve optimal interactions between

Recognition memory, which describes the ability to identify a studied item as previously encountered, is supported by two distinct types of retrieval: familiarity and recollection. Familiarity refers to a fast acting process that reflects a quantitative assessment of memory strength, whilst recollection is the retrieval of qualitative contextual information about a previous event. Detailed accounts of how retrieval is contingent upon familiarity and recollection have been proposed by Dual-process models (for review see Yonelinas, 2002). As well as empirical models, a range of computational episodic memory models have been proposed (Marr, 1971; McClelland et al., 1995). Most of these models regard retrieval as a generic read-out mechanism in the form of pattern completion. These models lack any attempt to incorporate the framework of Dual-process theory or address any specific questions concerning the mechanism of episodic retrieval. We propose an episodic memory model which is able to simulate episodic memory retrieval in the light of dual process theories. This model is able to perform both familiarity and recollection processes within a single attractor neuronal network. Familiarity discrimination is performed by using the different energy levels for old and new items (see Bogacz et al., 2001). A difficulty in modelling recollection with this network lies in the fact that for any given input the network will always settle into an attractor state. Thus, the challenge is to discriminate which attractor state refers to a previously studied (old) or unstudied (new) patterns. We introduce a recollection process which takes advantage of the different settling dynamics for old and new items, by determining the dot product of a networkis initial and attractor state given a particular test pattern. The results show that the recollection measure is able to discriminate between old and new patterns. However, the recollection discrimination is of smaller capacity compared to the familiarity discrimination. This is in line with empirical observation of episodic memory retrieval. In particular, the model incorporates the finding that there is a difference between the speed of familiarity and recollection, and that the two processes are functionally independent.

#### Grid-based Parallel Simulations of Mammalian Cortical Hypercolumn

Wojcik Grzegorz

Sunday Poster – S78

Large biological Hodgkin-Huxley neural networks are examined.Ensembles of simulated microcircuits model behaviour of some part of mammalian visual system. Good simulation of large groups of Hodgkin-Huxley neurons usually requires high computational powers. The modular structure of visual system seems to be appropriate task for grid computations. In this paper we report results of Polish Cluster of Linux Systems (CLUSTERIX) grid application to modelling of vision processes. MPGENESIS simulator is used for all simulations. We investigate networks consisting 64 thousands of Hodgkin-Huxley neurons. Such number of simulated neurons allowed us to observe liquid computing phenomena. In theory cortical microcircuits are treated as Liquid State Machines (LSM). The work of each machine resembles behaviour of particles in a liquid. Though, we also present some results confirming the thesis that neural liquids tend to be in different states for different, changing in time stimulations and that such biological structures can have computational power. Separation abilities of the investigated model as a function of Hodgkin-Huxley parameters and pattern complexity will be discussed in some detail.

medial-temporal lobe structures supporting mnemonic mechanisms and frontal lobe structures that support cognitive control such as memory organizational processes. Accumulating evidence suggests that both the frontal cognitive control mechanisms and the hippocampal associative memory processes are modulated by the dopaminergic systems. Furthermore, midbrain dopaminergic neurons, which are been known to modulate reward processing, also project to the hippocampus. Thus, a probable proposition is that midbrain dopaminergic reward modulation mechanisms may affect or interact with the frontalhippocampal episodic memory circuitry. It is well established that the efficacy of dopaminergic functions declines substantially in the prefrontal, hippocampal, and midbrain regions with increasing age (B‰ckman & Farde 2005, Marschner et al. 2005 for reviews). Although many studies have separately examined the effects of deficient dopaminergic modulation on the respective functions associated with these three brain regions during aging, much less is known about how aging-related decline in dopaminergic functions in these regions might interact with each other and affect the connectivity of the episodic memory circuitry. Our previous computational work showed that non-optimal dopaminergic modulation modeled as reduced stochastic gain tuning in neural networks reduces the representational distinctiveness of cortical signals and stimulus representations (Li, Lindenberger & Sikstr'm 2001). The aim of this paper is to explicitly model aging-related declines of dopaminergic modulation in the prefrontal, hippocampal, and midbrain regions, which in turn could contribute to less distinctive representations of prefrontal control signals, hippocampal memory associations, and midbrain reward signals. Such a multiple-region gain-tuning model allows us to computationally investigate the interactions between aging-related declines in reward processing and the frontalhippocampal episodic memory circuitry.

### Mean Field Analysis of Mexican-hat type Neural Network with Leaky Integrate-and-Fire Neurons

Kosuke Hamaguchi RIKEN Brain Science Institute, Tokyo, Japan hammer@brain.riken.jp Tuesday Poster – T55

The stability of stationary states of Mexican-hat type neural networks with leaky integrate-and-fire neurons is analytically studied. Mean field approach is applied to the analysis of the stability of network activity which is represented by a small number of order parameters. The order parameters are calculated in a self-consistent way. The boundaries between uniform, localized, spontaneous, and multi-stable phases are identified from the solution of self-consistent equations. The analytical solutions are confirmed with numerical calculations.

#### Neural network learning through trophic interaction

Kenneth Harris

Tuesday Poster - T90

Center for Molecular and Behavioral Neurosci Rutgers University, Newark, New Jersey, USA kdharris@andromeda.rutgers.edu

Artificial neural networks are both models of brain function, and information processing devices for real-world applications. However, the backpropagation algorithm most commonly used in applications cannot be used by the brain, as it requires fast

retrograde communication along axons. Here we describe how trophic interaction, a slower form of retrograde communication well characterized in the nervous system, can underlie learning in multilayered neural networks. A multilayer perceptron training algorithm is described, which outperforms backpropagation on a pattern classification task. Trophic interaction, essential for neural patterning during development, may also facilitate learning in neural networks.

Parameter Estimation in Single Compartment Neuron Models using a Synchronization Based Method	A biophysical model of short-term plasticity at the calyx of Held
Darrell Haufler Monday Poster – M7 France Morin Jean-Claude Lacaille	Matthias Hennig Monday AM Oral Michael Postlethwaite, Ian Forsythe, Bruce Graham School of Informatics, Edinburgh University, Edinburgh, UK <u>mhennig@inf.ed.ac.uk</u> , mp187@leicester.ac.uk
Frances Skinner	The calyx of Held is a giant glutamatergic synapse in the auditory system and
Toronto Western Research Institute, Toronto, Canada	displays multiple forms of short-term facilitation and depression. This study presents a detailed biophysical model of the short-term plasticity at this synapse.
haufler@gmail.com france.morin@umontreal.ca	Different experimentally characterised pre- and postsynaptic mechanisms on time scales ranging from milliseconds to several seconds were included, and their influence on activity-dependent short-term dynamics was investigated. The
We describe a method of estimating parameter values in single compartment neuron models from a recorded voltage trace. We use the voltage trace to drive the model which results in synchrony between the model and the corresponding state variables of the experimental system. Perfect synchrony holds only for correct parameter values but for all parameter values the model passively follows the recorded voltage trace. We define a cost function that characterizes the goodness of this synchrony and has its global minimum at correct parameter values. We argue that this cost function is well suited to optimization routines that take advantage of the gradient of the cost function. One advantage of this method is that the maximal conductance values do not have to be optimized along with the other parameters but rather can be easily computed once the other parameters have been found. We test our method using a previously developed single compartment model of a hippocampal interneuron. Through direct computation of the cost function routine using this cost function with several parameters in the model perturbed by between fi20% and 20% of their magnitude. The optimization is fast and	main components of the model are a mathematical description of the presynaptic vesicle dynamics, which include passive and activity-dependent recycling, calcium-dependent exocytosis and a kinetic model of postsynaptic AMPA receptors which was separately optimised against experimental data. Furthermore, metabotropic glutamate autoreceptors and calcium channel inactivation were investigated as additional presynaptic factors modulating the release probability. This model can faithfully reproduce the time course and amplitude of synaptic depression during repetitive stimulation at different frequencies. The key factors required to obtain these fits were fast activity- dependent vesicle recycling and a limited number of sites for exocytosis at each active zone. In addition, postsynaptic AMPA receptor desensitisation was found to have a significant effect at high stimulation frequencies. On the other hand, weak and slow fluctuations of the release probability did not affect the magnitude of the postsynaptic response, but instead led to changes in the size of the pool of releasable vesicles <b>Temporal Pattern identification using Spike-Timing Dependent Plasticity</b>
consistently returns accurate parameter values. In conclusion we believe that this technique will prove useful in the development of single compartment models when certain parameters are unavailable or impractical to measure.	Frédéric Henry Sunday Poster –590 Emmanuel Daucé, Hédi Soula Mouvement & Perception, Marseille, <u>fred@reveries.info</u> , edauce@egim-mrs.fr
Therapeutic rewiring by means of desynchronizing brain stimulation:         theoretical and experimental approaches         Christian Hauptmann       Tuesday AM Oral         Erwin-Josef Speckmann         Peter Tass         Research Center Juelich, Juelich, Germany         c.hauptmann@fz-juelich.de	In this paper we address the question of realistic reinforcement mechanisms which allow an agent to adapt its behaviour to fit a particular task. We focus on learning in a recurrent neural network and present a model where Spike-Timing Dependent Plasticity (STDP), a local hebbian learning rule inspired from biology, is used in conjonction with its ``opposite", the ``Anti-STDP". This is combined with a local regulation mechanism which maintains the neuron output in the bounds of a reference frequency, allowing the global dynamics to be maintained in a softly disordered regime (at the ``frontier of chaos"). We test this approach on a simple task which requires short-term memory : temporal pattern identification. The first results obtained seem interesting and promising and we hope this model to serve as a basis for more complex tasks.
speckma@uni-muenster.de	Criticality in Clustered Cortical Connectivity Sunday Poster –S30
We study anti-kindling effects of a desynchronizing multisite coordinated reset stimulation (MCRS) theoretically in a mathematical model and in experimentally in hippocampal slices. MCRS has robust long-term anti-kindling effects and is able to change the synaptical structure in the hippocampal network. This means, that during MCRS parts of the network unlearn its pathological synaptic connections, which might enable the network to reestablish a physiological level of connectivity. Our results are relevant for the application of desynchronization stimulation in multiple areas characterized by pathologic synchronization like Epilepsy and Parkinsonian disease.	Claus Hilgetag, Matthias Goerner, Marcus Kaiser International University Bremen, Bremen, Germany <u>c.hilgetag@iu-bremen.de</u> , matthias@math.berkeley.edu One of the essential challenges for extensive neural networks, such as the mammalian cerebral cortex, is to represent functions through stable activation patterns within a critical functional range. In this critical range, the activity of neural populations in the network avoids the extremes of either quickly dying out or spreading through the whole network. Moreover, the networks should be capable of creating a large number of different activation patterns, involving neural populations of different sizes, in order to perform diverse functions. Previous network models used a dynamic balance of inhibition and excitation to

et al. 2004, Trends Neurosci 27: 186

explain how brain activity stays in a critical range for function. Here we propose that the structural organization of neural networks also plays an important role in explaining their wide range of stable functional activation patterns. The connectivity of the mammalian cerebral cortex shows a clustered network organization across several scales, ranging from densely connected cortical columns to clusters of cortical areas linked by long-range fibers [1,2]. Using a simple percolation model, we investigated how functional activation spreads through such a hierarchically clustered network. The simulations demonstrated that stable and scalable activation patterns, persisting in the critical functional range and involving different sets of neural populations, could be produced in hierarchical cluster networks, but not in random networks of the same size. These findings indicate that a hierarchical cluster architecture may provide the structural basis for the diverse and stable functional patterns observed in cortical networks. [1] Hilgetag et al. 2000, Phil Trans R Soc Lond B 355: 91 [2] Buzsaki

Parallel Simulation with NEURON     Sunday Poster - S50       Michael Hines     Sunday Poster - S50	Stochastic modeling of inositol-1,4,5-trisphosphate receptors in Purkinje cell spine
Dept. Computer Science, Yale University, New Haven, Connecticut, USA	Katri Hituri Monday Poster – M24 Pablo Achard, Stefan Wils, Marja-Leena Linne, Erik De Schutter
michael.hines@yale.edu The NEURON program supports parallel simulation of network models in	Tampere University of Technology, Tampere, Finland <u>katri.hituri@tut.fi</u> , pablo@tnb.ua.ac.be
which cells on different processors are coupled by discrete logical spike events. The only requirement is that interprocessor network connections have a non- zero presynaptic spike generation to postsynaptic spike delivery connection delay since the minimum delay determines the integration interval at the end of which all spikes initiated in the just completed interval are sent to all machines. Parallel discrete event (PDE) simulations can be integrated with NEURON's fixed and variable step methods, including the local variable time step method. The PDE spike distribution mechanism's use of MPI_Allgather combines extreme simplicity with complete generality since communication overhead is essentially independent of network connectivity. NEURON also supports parallel simulation of gap junction coupled cells and synapses where postsynaptic state is continuously dependent on presynaptic voltage.	We propose here the first models of inositol-1,4,5-trisphosphate (IP3) receptors (IP3R) in a fully stochastic reaction-diffusion framework. The aim is to study the effects of stochasticity on IP3R functioning and Ca2+ dynamics in Purkinje cell spines. It is known that transient rises in the cytosolic calcium (Ca2+) concentration have an important functional role in Purkinje cell. The rises are due to the Ca2+ release from the extracellular space and intracellular stores, like endoplasmic reticulum (ER) and Ca2+ buffers. In Purkinje cell spines, the Ca2+-induced Ca2+ release from ER is mediated by IP3R. IP3R is relatively highly expressed in Purkinje cell and have a major role in long-term depression (LTD) induction. Several models have been proposed for the behavior of IP3R. Until the recent years, all the IP3R models and simulations were deterministic. However, when biochemical reactions happen in very small volumes, such as

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# Model of VOR motor learning with spiking cerebellar cortical neuronal network

Yutaka Hirata	Tuesday Poster – T61
Kayichirou Inagaki, Pablo Blazquez, Stephen Highstein	1

Chubu University College of Engineering, Aichi, Japan yutaka@isc.chubu.ac.jp, uinak@solan.chubu.ac.jp

The vestibuloocular reflex (VOR) stabilizes retinal image during head motion by counter-rotating the eyes in the orbit. The VOR is under adaptive control which maintains the compensatory eye movements under the situation where growth, aging, injury, etc, may cause changes in oculomotor plant dynamics. Its adaptive control requires the cerebellar flocculus (FL). Cerebellar cortical long term depression (LTD) or the combination of LTD and LT-potentiation can successfully account for the adaptive changes in the VOR that are conventionally characterized by changes in its gain (eye velocity/head velocity) and phase shift at a certain frequency. However, these simple models cannot explain changes in the dynamics of the VOR manifest when tested by velocity steps of head rotation, or the VOR adaptation in which differential gain changes are required for up/down, left/right, or high/low frequency head rotation. The output of FL, Purkinje cell, produces 2 types of action potential, called simple and complex spikes. The simple spike (SS) fires at several hundreds Hz, while the complex spike (CS) fires at ultra-low frequency (~5Hz). While SS encodes motor or/and sensory related signals in their firing rate, CS is thought to code an error signal used for motor learning or a motor related signal in their spike timing. However, a recent study demonstrated that VOR adaptation occurs up to 50 Hz of head rotation, at which SS firing frequency is no longer reliable for rate coding. Further, Purkinje cell SS firing has very large variability that conventional cerebellar models assuming rate coding often neglect. The SS firing variability may be essential in cerebellar information processing as the theory of stochastic resonance suggests. To aid in the understanding of the signal processing in the FL during VOR adaptation, we currently constructed a VOR model with spiking cerebellar cortical neuronal network based upon the known anatomy and physiology. Model simulations confirmed that the model could reproduce experimental Purkinje cell SS firing patterns and eye velocity profiles during various paradigms, assuring its validity in evaluation of signal processing in cerebellar cortex, and interaction of cerebellum with other parallel structures in VOR circuitry. The model will be used to evaluate roles of synaptic plasticities in motor learning that have been discovered in the cerebellar cortical neuronal network mostly in vitro. Also the model can be used to elucidate the roles of spike occurrence timing and to theorize the spike timing based VOR learning mechanisms.

lendrific spine, the number of molecules is low even with fairly large concentrations. The small number of molecules increases randomness in the biochemical reactions. For this reason it is necessary to use stochasticity in models and simulations to get more realistic results. In the recent years, several stochastic approaches to model and simulate the IP3R dynamics have been introduced. None of these models takes account the stochastic diffusion of the molecules and ions in the cytosol or in the lumen of ER and the effect of several IP3Rs has been studied only when they are clustered together. In this study, the STochastic Engine for Pathway Simulation (STEPS) was used to simulate the dynamics of IP3Rs. STEPS extends Gillespie stochastic simulation algorithm (SSA) with the ability to simulate the diffusion of molecules through compartments in three dimensions. The GENESIS/Kinetikit simulation environment was used produce the deterministic simulation results of the models to compare with the stochastic ones. We implemented several IP3R models into STEPS and GENESIS/Kinetikit. With small concentrations, the stochastic simulations give different result compared to the ones obtained with deterministic simulations. Our results also indicate that the effect of stochasticity is significant below certain concentration values. In the future, our work will promote the development of realistic compartmental models for the Purkinje cell spines and associated intracellular dynamics.

# The significance of gap junction location in striatal fast spiking interneurons

Johannes Hjorth Alex Henna Elias Jeanette Hellgren Kotaleski Tuesday Poster – T36

Royal Institute of Technology (KTH), Sweden, Stockholm, Sweden

hjorth@nada.kth.se alhe02@kth.se

Fast spiking interneurons (FS) in the striatum are hypothesised to control spike timing in the numerous medium spiny projection neurons (MS) by inhibiting or delaying firing in the MS neurons. The FS neurons are connected to each other through electrical gap junctions. This might synchronise the FS neurons, leading to increased influence on target neurons. Here we explore the possible difference between proximal and distal gap junction locations. Somatic and distal dendritic gap junctions with equal coupling coefficient, as defined for steady-state somatic inputs, showed significantly different coupling coefficient with transient inputs. However, the ability to synchronise spiking in pairwise coupled FS neurons, which received synaptic inputs as during striatal upstate periods, was as effective with distal gap junctions as with proximal ones. Proximal gap junctions, however, caused synchronisation within a more precise time window.

### The mechanism of LTP affects dendritic computation

Bill Holmes Monday Poster – M34 Lawrence Grover

### Ohio University, Athens, Ohio, USA

### holmes@ohiou.edu, grover@marshall.edu

Experimental evidence supports a number of mechanisms for the synaptic change that occurs with long-term potentiation (LTP) including insertion of AMPA receptors, a change in AMPA receptor single channel conductance, unmasking of silent synapses and a change in the probability of vesicle release. Here we combine experimental and modeling approaches to determine if LTP with these various mechanisms might affect dendritic computation differently. Whole cell patch recordings measured somatic EPSP amplitude in response to near minimal afferent stimulation before and after LTP induction. Detailed neuron and synapse level models were constructed to fit experimental data and estimate quantitatively increases in the number of AMPA receptors per synapse, AMPA single channel conductance, or number of synapses activated per test stimulus that matched post-LTP experimental results. In these fits more depolarized potentials were found near activated synapses when AMPA single channel conductance or the number of AMPA receptors were increased than when the number of activated synapses was increased. We conclude that post-LTP stimuli are more likely to lead to activation of local voltage-dependent conductances when LTP is an increase in AMPA single channel conductance or an increase in the number of receptors than when LTP is an increase in the number of activated synapses.

#### A means to an end: validating models by fitting experimental data

Mark Humphries Kevin Gurney Tuesday Poster – T42

University of Sheffield, Sheffield, UK

m.d.humphries@shef.ac.uk k.gurney@sheffield.ac.uk

The acceptance or rejection of a computational model, be it during the development or publication process, can often hinge on the accurate replication of experimental data. It is therefore essential that the modeler has an excellent grasp of the possible interpretations of that data, so that models are not incorrectly rejected or accepted. We argue here that some consideration of the properties of the data, particularly the underlying experimental design, is essential in guiding the design of the simulations of that model. For anything more complex than a fit to trends in the data, we advocate a ``models-asanimals" protocol in which the number of animals and cells sampled are exactly matched by the number of models simulated and artificial cells sampled: these parameters will have a considerable impact on the statistical properties of the experimental data, and so must be accounted for when generating simulated data. We use examples from our replication of a whole-cell recording study with a model of the basal ganglia to illustrate this protocol. In doing so, we illustrate three deep-rooted problems with assessing fits to experimental data. First, the experimental data is itself a sample of a much larger population: it is thus essential that the correct statistic and its error bounds are compared between data and model results. Second, most experimental data are reported in a manner that assumes a normal distribution of the variable in the underlying population. Lognormal and power-law distributions are common in real-world data, and the model results illustrate a log-normal distribution underlying a mean experimental variable that was apparently closely-fitted. Third, the low sample size and small variation in much neuroscience data prevents formal assessments of deviations from normality in distributions of experimental variables. We conclude that, as many of these problems are due to the technical limitations of neuroscience experiments, the onus is on the modeler to be aware of them and assess their impact on fits between experimental and simulation data.

# Tonically driven and self-sustaining activity in the lamprey hemicord: when can they co-exist?

Mikael Huss Martin Rehn Tuesday Poster – T48

KTH, Stockholm, Sweden

hussm@nada.kth.se, rehn@nada.kth.se

Unilateral rhythmic activity is found in short hemisegmental preparations of the lamprey spinal cord. Such activity can be elicited either by tonic activation using, for example, bath-applied D-glutamate, or by brief electrical stimulation. In the former case, stable frequencies between 2 and 10 Hz can be achieved, but in the latter case, the preparations can show a fast self-sustaining rhythm (a "locomotor bout") which is about 15 Hz just after the stimulus has been withdrawn after which it is gradually slowed down, presumably by an activitydependent process. We want to examine under what conditions both of these types of activity can co-exist in an excitatory network. We use a network of simple spiking neurons to simulate an excitatory network. We analyse our simulation results using a conceptual model, inspired by dynamical systems theory. Specifically, we assess the importance of the NMDA synaptic time constant for the frequency range available to the network. We find that while our conceptual model can explain the experimental findings in principle, we are unable to quantitatively replicate the results with the given network configuration. Networks with a relatively rapidly decaying NMDA conductance can access the lower frequency range (2-10Hz) corresponding to tonically activated networks, but they do not display bouts. Networks with more slowly decaying NMDA conductances display locomotor bouts but can tonically access only very low frequencies.

#### Detection of synchronization in event-related potentials by clustering

Axel Hutt Michael Schrauff Sunday Poster – S9

Humboldt University Berlin, Berlin, Germany

axel.hutt@physik.hu-berlin.de michael.schrauf@daimlerchrysler.com

The present work studies the application of a cluster algorithm to multivariate evoked potentials in order to extract adaptively time windows of cognitive components. The event-related brain potentials were obtained from an auditory oddball experiment while real car-driving and we find the lack of the cognitive component P300 in an experimental condition. Further the obtained results indicate attention effects in the event-related component N100 and shows dramatic latency jitters between single datasets.

#### Optimal helplessness: a normative framework for depression

Quentin Huys, Peter Dayan	Sunday Poster – S88
Gatsby Unit, UCL, London, UK	
qhuys@gatsby.ucl.ac.uk, dayan@gatsby.ucl.ac.uk	

Depression is a hugely debilitating disease afflicting millions of people. As for most psychiatrical conditions, it is hard to characterize precisely the set of underlying neural problems, except to say that neuromodulatory systems, notably dopamine, serotonin and norepinephrine, all seem to play key roles, based on pharmacotherapy and a variety of more or less valid animal models. Surprisingly, the recent wealth of accounts of the role of these very neuromodulators in the sort of normal cognitive functions that are disrupted in depression, schizophrenia and the like, have yet to be fully informed by (or indeed themselves to inform) the characteristics of the psychiatric conditions. Depression, and particularly the simpler popular animal models of the disorder such as learned helplessness (LH, and chronic mild stress (CMS), suggest two gross features of neuromodulatory systems that have not hitherto attracted much attention. The one we consider here is neuromodulatory metaplasticity, the notion that there are different gross states of adaptation (which we call attitudes) of neuromodulatory responsivity. Depression has been characterized in terms of affective blunting, reducing the import of not only rewards, but punishments too . We consider this a normative allostatic adaptation to a particular structure of environmental rewards and punishments. Whether the transition into this attitude from a normal attitude is occasioned merely by the statistics of rewards and punishments (in a more Pavlovian manner) or as an optimal internally-directed 'action' (in a more instrumental control strategy) is presently unclear. The second feature of neuromodulation is rich dynamical feedback interactions between the different systems, as suggested by both the natural history of disorders and the timecourse of action of drugs. These interactions will exert significant influence over the transition into a depressed attitude, and the apparently maladaptive persistence of this attitude in depressed patients. Unfortunately, since the major animal models do not exhibit the persistence, it is hard to get even qualitative constraints on this process. Here, we focus on neuromodulatory metaplasticity, characterizing the depressed attitude engendered by LH and CMS in normative terms as an appropriate response to statistics of reward and punishment. We show that these paradigms induce conditions under which the optimal strategy is a form of extreme selfpreservation, and in which, therefore, the actual values of rewards and punishments are severely blunted. We start by describing the models; then develop our normative model, and finally draw some broader conclusions.

### Model-based optimal interpolation and filtering for noisy, intermittent biophysical recordings

Quentin Huys, Liam Paninski Monday Poster –M5 Gatsby Unit, UCL, London, UK <u>ghuys@gatsby.ucl.ac.uk</u>, liam@stat.columbia.edu

Noise is an omnipresent issue that is often handled suboptimally. For example, noise is an issue in voltage-sensitive imaging -- even the best dyes achieve signal-to-noise ratios of no more than ~1-6%. Averaging noise out is not always possible and sometimes not even desirable. Missing data are often burdensome too: in voltage dye experiments, the laser has to be moved between sites of interest and thus the data is not acquired simultaneously, leading to gaps in the data. Despite advances , this problem becomes more prominent the more sites one attempts to record from. More generally, we might even be interested in a variable that has not been observed directly at all, such as the voltage in a Ca2+ imaging experiment. Principled methods to filter out noise, to interpolate between data points and to infer unobserved variables could substantially complement advances in data acquisition methodology. Here we show how, when time series recordings of a dynamical system (eg the voltage of a cell) are made, knowledge of the dynamical system can be used to both filter and interpolate between the measurements, providing a principled alternative to heuristics such as temporal smoothing or low-pass filtering. Neural dynamics may often be specified as Markov processes (e.g., stochastic differential equations). If these dynamics are not directly observable (``hidden,' due to noisy or indirect measurements), the task of recovering the distribution over the true underlying state evolution **0:T** of the neurone over time  $p(s p(bfs_{0:T}|V_{0:T}))$  is equivalent to inference in nonlinear state space models. These models, together with their discrete analogues such as intermittent Kalman filters and Hidden Markov Models have been analysed extensively and are very well understood. In particular, if the hidden variables do indeed evolve in a Markovian manner (as is often the case), a number of algorithms from the machine learning literature allow efficient sampling from  $\bar{v}(bfs_{0:T})V_{0:T})$ , despite the huge size of this state space  $O(N^T)$  for a state space of size N). In particular, we find that the combination of a nonlinear Gaussian state space model with Gaussian observation noise and the forward-backward particle filter -- a simple algorithm frequently applied to Hidden Markov Models -- allows accurate recovering of the true voltage of a Fitzhugh-Nagumo (FHN) spiking model.

# Postsynaptic modulation of electrical EPSP size investigated using a compartmental model

Monday Poster -M29

Ovidiu Iancu Patrick Roberts Jianmei Zhang Curtis Bell

Neurological Sciences Institute, Oregon Health Sciences University Beaverton, Oregon, USA

diancu@bme.ogi.edu robertpa@ohsu.edu

The mormyrid electric fish displays extremely fine temporal resolution as measured in behavioral studies. The first stage of sensory processing, the sensory afferents, also display very precise temporal responses to electrical stimulation. The afferents are connected through gap junctions to the granular cells, which in addition receive a corollary discharge signal at the time of the electric pulse. The granular cells have a relatively long time constant, seemingly at odds with their presumed role as coincidence detectors. We use experimental data to build a compartmental model that investigates the mechanism by which the relative timing of the two inputs to the granular cells determines the effect of the afferent spike through the electrical synapse.

Induction of Synaptic Depression by High Frequency Stimulation in Area CA1 of the Rat Hippocampus

Kazuhisa Ichikawa Hoshino Akemi Kunio Kato Tuesday AM Oral

Kanazawa Institute of Technology, Department of Brain and Bioinformation Science Hakusan Ishikawa, Japan

ichikawa@his.kanazawa-it.ac.jp natsu5888@hotmail.com

It is generally accepted that low frequency stimulation (LFS) induces long-term depression (LTD), while high frequency stimulation (HFS) induces long-term potentiation (LTP). We performed modeling and experimental studies to see whether this commonly accepted view is the case for a wide range of stimulation frequencies or not, and found the induction of LTD by high-frequency stimulation of 300Hz (HFS-LTD) both in simulation and experiments. First, we constructed a model for synaptic plasticity based on biochemical reactions in a spine. The model included Ca2+ flow through NMDA receptor channels, Ca2+ binding to calmodulin and buffers, activation of Ca2+/calmodulin-dependent protein kinase II (CaMKII), and calcineurin (CaN). The simulation results suggested the induction of LTD and LTP at stimulation frequencies form 1 to 12Hz and from 12 to 200Hz, respectively. At stimulation frequency higher than 200Hz, however, the simulation suggested the induction of LTD (simulated HFS-LTD). Next, we performed experiments for the induction of LTP and LTD. Field EPSP was recorded from rat CA1 region by stimulating Schaffer collateral-commissural fibers from 2 to 300Hz with constant duration of 1sec. Experimental results showed the induction of LTD and LTP at stimulation frequencies lower than 10Hz and those between 10 and 200Hz, respectively, which are basically the same as those reported from other laboratories. At stimulation frequencies higher than 200Hz, however, the induction of LTD was observed again (experimental HFS-LTD). Thus, HFS-LTD was observed both in simulations and experiments. Next, we tested the occlusion of HFS-LTD with standard LFS-LTD. HFS-LTD was occluded by standard LFS-LTD induced by 1Hz-15min stimulation. HFS-LTD was blocked by D-AP5, but not by Ni+ (Ttype voltage-gated calcium channel blocker) nor nimodipine (L-type voltagegated calcium channel blocker). Inhibition of CaN or CaMKII blocked HFS-LTD. Finally, we analyzed the model to find a possible mechanism for HFS-LTD in our experiments. The analysis showed that low and high increase in [Ca2+]i resulted in lower and higher concentration of activated CaMKII ([CaMKIIact]) than that of CaN ([CaNact]) suggesting the induction of LTD and LTP, respectively. Further increase in [Ca2+]i, however, lower [CaMKIIact] than [CaNact] was observed again suggesting the induction of HFS-LTD. These results suggest that the crossing of activation curve of CaMKII twice with that of CaN as the increase in [Ca2+]i will be a possible mechanism for the induction of HFS-LTD in our experiments.

Stimulus-Driven Synaptic Pruning and Spatio-Temporal Patterns of Activity in Large Neural Networks	Comparison of DCN neuron rebound firing between in vivo and in vitro conditions: A modeling study
Javier Iglesias Tuesday Poster – T84 Alessandro E.P. Villa	Dieter Jaeger Tuesday Poster – T63 Volker Steuber
University of Lausanne, Lausanne, Switzerland javier.iglesias@unil.ch alessandro.villa@ujf-grenoble.fr	Dept. Biology, Emory Univ., Atlanta, Georgia, USA djaeger@emory.edu, v.steuber@ucl.ac.uk
The cerebral cortex has come to be associated with a remarkable capacity for functional and anatomical plasticity during pre and postnatal development periods. Adult patterns of neuronal connectivity develop from a transient embryonic template characterized by exuberant projections to both appropriate and inappropriate target regions in a process known as synaptic pruning. Trigger signals able to induce synaptic pruning could be related to dynamic functions that depend on the timing of action potentials. In a simulated development experiment, we stimulated locally connected random networks of spiking neurons, and observed the effect of a STDP-driven pruning process on the emergence of cell assemblies, and the detection of spatiotemporal patterns of activity among them.	Six basic voltage-gated conductances were adjusted in the model until it was able to accurately reproduce basic electrophysiological properties such as spike waveforms and spike rates with and without current injection. In addition, 3 modulatory voltage-gated conductances (IH, T-type calcium, persistent sodium) were included in the model, which contribute to rebound responses following - cips in our physiological data. We examined the dependence of rebound responses on each current for different current densities and different -cip
Development and application of CMS based database modules for neuroinformatics	amplitudes and durations. We found that the persistent sodium current is responsible for a long lasting rebound, expressed by an speedup in spike frequency for over 1s. In contrast, the T-type calcium current produced a shorter, high-frequency spike burst. Interestingly, the H current by itself could
Hidetoshi Ikeno Sunday Poster –S45 Takuto Nishioka Takuya Hachida Ryohei Kanzaki	produce a weak fast rebound, but in combination with T-type calcium current reduced the fast rebound response through shunting, and prevented repetitive bursting. We then included an in vivo like baseline of excitatory and inhibitory synaptic input in the model. Rebounds were now again stimulated with -cips, as
Yoichi Seki Izumi Ohzawa Shiro Usui	well as with strong bursts of inhibitory input. We found that a high level of synaptic background significantly reduced the amplitude of rebound responses through shunting. Nevertheless, a primarily dendritic T-type calcium rebound was still present, and NMDA currents could further support a dendritic rebound
School of Human Science and Environment University of Hyogo, Himeji, Japan	response. Supported by: NIMH RO1 065634 (DJ) and HFSPO (VS)
<u>ikeno@shse.u-hyogo.ac.jp</u> , n_takuto@cancer.livedoor.com	An integrative neural network model for the negative priming effect of Stroop task performance
In order to utilize the accumulation of expertise effectively, it is important to integrate research resources from laboratory to international levels. Recently, applications of Content Management System (CMS) have become wide spread for constructing WWW portal sites. Taking advantage of these resources for	Jaeseung Jeong Sunday Poster –S4 Dongil Chung, Jaewon Lee, Amir Raz
neuroscience, we have applied the CMS technologies in order to construct an effective resource managing environment in the laboratory. In this paper, we present database modules: PubMedPDF and CosmoDB, which can provide data	Department of Biosystems, KAIST, Daejeon, South Korea
integration and sharing capabilities for bibliographical resources and archived data files. These modules were developed under the PHP based CMS	lonlysnow@gmail.com
environment: XOOPS. As the result of application of these modules to our laboratory works, it was shown their effectiveness on biological and neuroscience fields.	The negative priming (NP) effect is characterized by an increase in reaction time for identification of a current target stimulus that has been employed as a distractor stimulus feature on the previous trial, which is often observed during
<b>Computation With Spikes</b> Tuesday Poster –T17	the Stroop task. The neurobiological mechanism underlying this effect is not yet known. Based on the observation that the degree of NP effect is different depending on the combinations of types of two successive stimuli, we divided
Eugene M. Izhikevich	the NP into four subgroups (NP1, NP2, NP3, and NP4) according to the degree of interferences (disinhibition) between the successive stimuli. We found that
The Neurosciences Institute, San Diego, California, USA eugene.izhikevich@nsi.edu	four NP subgroups had significantly different mean reaction times in the Stroop task for 55 healthy subjects, indicating that the NP effect is heterogeneous with a broad spectrum of degrees of disinhibition based on successive stimuli. Toward
I will review probably the most beautiful theoretical idea in neuroscience synfire chain hypothesis by M. Abeles and its extension synfire braid hypothesis by E. Bienenstock. Both hypotheses emphasize the role of spikes, rather than firing rates, in the information processing by the brain. Both hypotheses were severely criticized by some neuroscientists on the basis that the existence of synfire activity requires unrealistic spike reliability, fine-tuning of	a more integrative understanding of the NP effect in Stroop task performance, we constructed to modify a parallel distributed processing (PDP) model, originally developed by Cohen et al. (1990), which can simulate the Stroop and NP effect. Our model, the time-delayed neural network (TDNN) model,

existence of synfire activity requires unrealistic spike reliability, fine-tuning of synaptic weights, special distribution of connectivity, etc. Using a minimal yet that only facilitates the corresponding input nodes of the current stimulus. We realistic spiking model, I will demonstrate that neurons with conduction delays showed that this TDNN model could capture essential features of the NP effect and STDP can spontaneously self-organize into groups capable of producing observed in human Stroop task performance, particularly the inhibitory patterns of self-generated stereotypical synfire activity. Interestingly, the number heterogeneity of NP effect. This finding suggests that working memory and the of such patterns could be much greater than the number of neurons in the memory retrieval process play a critical role in the NP effect during Stroop task network, suggesting an unprecedented memory capacity of the system. This performance. spontaneous self-organization is similar to the phenomenon of pattern formation in nature, and it is quite difficult to avoid, at least in models. Therefore, synfire activity may be a robust regime of functioning of spiking neurons. I will speculate on the significance of such activity to cognitive neural computations, to binding and gamma rhythm, and to a possible mechanism of attention.

Efficient model-based information-theoretic design of experiments		Detecting Correlated Population Resp
Lewi Jeremy	Sunday Poster – S76	Don Johnson
Robert Butera		Jyotirmai Uppuluri
Liam Paninski		
		Rice University, Houston, Texas, USA
Georgia Institute of Technology, Atlanta, G	eorgia, USA	
6	6 )	dhj@rice.edu
gtg120z@mail.gatech.edu		dhj@rice.edu juppu@rice.edu
rbutera@ece.gatech.edu		

We apply an information-theoretic approach to optimal experimental design in the context of estimating the unknown parameters of a parametric model of a neuron's response. Our goal is to intelligently pick the stimulus on each trial so as to minimize the error in the estimated parameters. We present an algorithm to choose the optimal stimulus on each trial by maximizing the mutual information between the neuron's expected response and the unknown parameter values. Previous theoretical work (Paninski 2005) has proven that this approach generally does better and never worse than random sampling. However, this previous work did not address the challenge of performing the optimizations for complex models rapidly enough to be useful in a real experiment. The guaranteed benefit rested on the assumption that the true maximum of the mutual information could be found, an assumption which appears difficult to meet, particularly with complex, nonlinear, multi-neuron systems. The present work demonstrates that, with a few approximations, we can in fact tractably perform these optimizations for a class of reasonably complex neural models. We model neurons as point processes whose conditional intensities are given by a generalized linear model (GLM). This class of models includes the classical linear-nonlinear (LN) cascade class of models (this is the "baseline" model in the sensory literature) as a special case, but more generally can incorporate terms corresponding to spike history and interneuronal coupling effects. We show that, with some classical (Gaussian) approximations of the posterior distributions of the GL model parameters given the observed spike and stimulus data on the first N trials, we can reduce the maximization of the mutual information (originally a very high-dimensional optimization problem) to a couple of simple, quite tractable 1-d optimizations. Despite these approximations our algorithm still achieves improvements over random sampling (and asymptotically gives exactly the improvements guaranteed by the theory in Paninski 2005). Therefore, this work describes an implementation of information maximization in experimental design which can be scaled to handle complex, nonlinear, population models of neural systems.

#### Neural representations underlying learning and memory: critical analysis for experimental data

Adam Johnson Neil Schmitzer-Torbert Paul Schrater David Redish

Tuesday Poster - T6

Center for Cognitive Sciences University of Minnesota, Minneapolis, Minnesota, United States

john5726@umn.edu nctorbert@hotmail.com

We examine use of decoding methods in analyzing learning and memory. This basic treatment suggests that what have previously been considered errors in reconstruction may reflect information rich dynamics critical to understanding task learning and solution. We applied this treatment to spiking data from the hippocampus recorded while rats performed a sequential choice task called the multiple/textsf{T}. Spatial representations within the dorsal hippocampus displayed development as a function of lap number and lap outcome (correct/incorrect). These data suggest that hippocampal representations may either develop spatial tuning or be related to changing mixture of non-local spatial mnemonic processing and local non-mnemonic processing states. Further analysis using decoding algorithms that operate at multiple timescales suggests these changes likely reflect mnemonic processes contributing task solution including route replay and choice evaluation. In sum, this treatment suggests that the hippocampus transitions from mnemonic processing states where neural representations of space are not necessarily localized to the animal's current position to non-mnemonic processing states in which neural representations are highly localized to the animal's current position.

#### onses

A critical step in analyzing neural population data is determining how the component responses depend on each other. Mathematically, we need a context---a model---within which to analyze the data, but which model is most appropriate? Because the number of parameters needed to describe binned data recorded from N neurons grows exponentially in N, the number of possible models also grows exponentially. We describe the normalized maximum likelihood model selection method and apply it to simulated data. This approach, derived using information theoretic techniques, has provably optimal model selection properties. Despite its optimality, we find that determining the correct model with limited data can frequently lead to incorrect model choices. We thus argue that without prior information or infeasibly large amounts of experimental data, no technique can be better. Consequently, determining a large populationis neural code faces theoretical obstacles.

#### Predicting Neuronal Activity with Simple Models of the Threshold Type

Renaud Jolivet Claudia Clopath Alexander Rauch Hans-Rudolf L scher Wulfram Gerstner

EPFL, Lausanne, Switzerland

renaud.jolivet@a3.epfl.ch claudia.clopath@epfl.ch

Evaluating the predictive power of simple models of the Integrate-and-Fire-type and developing systematic methods to construct such models from actual recordings has experienced a great deal of popularity in recent years. However, the question is still open of how the predictions of Integrate-and-Fire-type models compare to the precise structure of spike trains in the cortex. Extending and improving preexisting methodologies; our laboratory has developed a technique to extract relevant parameters from in vivo-like voltage traces. Our methodology was successfully applied to actual recordings of cortical neurons and we were able to confirm and extend the results of precedent reports. We found that a simple Integrate-and-Fire-type model is able to accurately predict both the subthreshold fluctuations and the exact timing of spikes within the limits imposed by the input-dependent intrinsic reliability of the neuron. Our results suggest that layer 5 neocortical pyramidal neurons under random current injection behave very much like Integrate-and-Fire neurons including a spikefrequency adaptation process. Our results can be viewed as a strong a posteriori justification to the use of this class of model neurons in large scale network studies. They also indicate that the picture of a neuron combining a linear summation in the subthreshold regime with a threshold criterion for spike initiation is good enough to account for much of the behavior in an in vivo-like lab setting. This should however be moderated since several important aspects including dendritic non-linearities, backpropagating action potentials and dendritic spikes are excluded. Our results illustrate as well the importance of two features of neuronal dynamics. Firstly, we found that adaptation is a necessary component in the model to connect between various driving regimes. Secondly, while it is relatively easy to correctly predict the subthreshold dynamics, it is difficult to find an efficient criterion to decide when to elicit spikes. A two-dimensional Exponential Integrate-and-Fire model therefore seems ideally suited to deal with these issues. It includes an additional mechanism that can be tuned to model spike-frequency adaptation but that is not restricted to this specific neuronal feature. Moreover, the balance equation for voltage includes an exponential term which describes early activation of voltage-gated sodium channels. This last addition allows to model specific behaviors like delayed spike initiation and offers flexibility at the level of the threshold mechanism. For the latter model, application of existing mapping techniques to recordings of cortical pyramidal neurons is under study at the moment.

Monday Poster – M21

#### Na,K-ATPase-Specific Spike-Frequency Adaptation

Renaud Jolivet, Pierre Magistretti	Monday Poster –M22
EPFL, Lausanne, Switzerland	
renaud.jolivet@a3.epfl.ch, pierre.magistretti@epfl.ch	

Spike-frequency adaptation is exhibited by almost all neurons that generate action potentials. It is a widespread phenomenon present in peripheral and central systems of both vertebrates and invertebrates and plays an active role in signal processing. We wanted to explore specifically spike-frequency adaptation that may originate from the activity of the electrogenic Na,K-ATPase pump and its link to metabolism. Using an Hodgkin-Huxley-type model including a calcium-gated mAHP current plus an Na,K-ATPase pump, we studied the neuronal response to long sustained tonic stimulation. We found that the electrogenic pump induces spike-frequency adaptation with a long time scale of the order of a few seconds to a few tens of seconds. The effective late adaptation time constant is the result of a complex interaction between the mAHP current and the electrogenic pump. Interestingly, this interaction takes place even below frequencies where calcium accumulates with consecutive spikes. Overall, the resulting pattern of instantaneous frequency that is generated is very similar to what is observed in in vitro recordings. The joint effect of the two mechanisms is analyzed in the context of a recently proposed universal model of spikefrequency adaptation. For weak stimulations, the electrogenic pump induces phasic spiking. Spiking stops after a few seconds even though the stimulation is maintained. Interestingly, this type of behavior cannot be obtained with the mAHP current alone. While calcium entry is entirely dependent on spiking, sodium continues to flow in the neuron through voltage-gated channels even after spiking has stopped if the membrane is sufficiently depolarized. This process approximately linearly converts the stimulus amplitude in a finite number of spikes. For stronger stimulations, the model behaves approximately as a type I neuron. These results illustrate the importance of sodium as a messenger for long-term signal integration. They point to a potential role for the Na,K-ATPase electrogenic pump in signal processing at frequencies accessible in vivo indicating a possible direct connection between input integration in neurons and brain metabolism.

## Multi-clustered cortical networks arise from developmental time windows for spatial growth

Marcus Kaiser, Claus Hilgetag Sunday Poster –S31 University of Newcastle, School of Computing Science Newcastle upon Tyne, UK <u>m.kaiser@ncl.ac.uk</u>, c.hilgetag@iu-bremen.de

Multi-clustered cortical networks arise from developmental time windows for spatial growth Marcus Kaisera,b,\* and Claus C. Hilgetagb a School of Computing Science / Inst. of Neuroscience, University of Newcastle, U.K. b School of Engineering and Science, International University Bremen, Germany Neural networks, from the neuronal network of C. elegans to connectivity among cortical areas of the Macaque monkey, are organized into clusters, with many connections within but few between clusters. In addition, connected nodes are often spatially close [1]. We recently proposed an algorithm for the spatial growth of biological networks in which the probability for establishing connections was higher for nearby than for distant nodes [2, 3]. While characteristic path length and clustering coefficient of the simulated networks were comparable to cortical networks, there was no guarantee that multiple clusters would arise. Furthermore, in cases where multiple clusters occurred, their size could not be controlled by the parameters of the spatial growth model. Therefore, we here explored developmental time windows as an additional developmental factor. The development of many cortical areas overlaps in time but ends at different time points, with highly differentiated sensory areas finishing last [4]. Based on this observation, we explored a wiring rule where the establishment of a connection between two areas depended both on their distance as well as the respective time windows for connection establishment. This extended algorithm was able to generate multiple clusters depending on the number and overlap of the different time windows. This suggests a possible link between temporal domains for connection establishment and the cluster architecture of neural systems. However, further experimental studies will be needed to test if time windows are crucial for cluster formation in vivo. [1] Hilgetag CC, Kaiser M (2004) Neuroinformatics 2:353?360. [2] Kaiser M, Hilgetag CC (2004) Phys Rev E 69:036103. [3] Kaiser M, Hilgetag CC, (2004) Neurocomputing 58?60:297?302. [4] Rakic P (2002) Nature Rev Neurosci 3:65?71

# Interneurons control hippocampal network dynamics in a subtype-specific manner

Szabolcs Kali Tamas F. Freund Tuesday PM Oral

CNS, Budapest, Hungary

kali@koki.hu freund@koki.hu

The activity and plasticity of principal neurons in cortex are regulated by a variety of inhibitory interneurons, which target different regions of the cell, often mimicking the arborization patterns of specific excitatory afferents. We investigated through computer simulations the possible roles of some specific types of interneuron in elementary computations in cortical networks. Morphologically and biophysically detailed compartmental models of hippocampal pyramidal neurons were used to study the processing and interaction of excitatory and inhibitory synaptic inputs at the single cell level. The two major excitatory inputs, the perforant path (PP) and the Schaffer collaterals (SC), had very different properties in terms of their efficacy and integration. In particular, the PP showed highly nonlinear integration, and evoked a significant somatic response only when it triggered non-local, large amplitude active events in the apical dendrites. Such dendritic spikes could be gated in an all-or-none fashion by appropriately timed inhibition via dendritic inhibitory neurons (e.g., O-LM cells). On the other hand, perisomatic inhibitory neurons (such as basket cells) effectively modulated the response to SC input, but not to PP input. We also constructed simplified models of CA1 pyramidal cells using a newly developed procedure for the systematic reduction of compartmental neuronal models, and combined them with active singlecompartment models of basket and O-LM interneurons in simulations of the hippocampal network. Principal cell activity levels in response to SC input were a monotonic function of input frequency, and were most effectively regulated by basket cell-mediated (feedforward as well as feedback) inhibition. In contrast, the response to PP input was a non-monotonic function of input frequency due to interactions with active dendritic events, and was more effectively controlled by O-LM cells. Finally, we found that networks comprising reciprocally connected pyramidal and O-LM cell populations were capable of generating theta frequency oscillations when driven by (non-oscillating) input through the PP. These oscillations required that both afferent input and feedback inhibition target the distal apical dendrites of CA1 pyramidal cells, and depended on the generation of dendritic spikes, but were insensitive to many details of the model cells and network, and persisted in large networks.

### Temporal Code and Inter-spike Interval distribution

Kukjin Kang Haim Sompolinsky Sunday Poster –S24

RIKEN, Brain Science Institute, Wako, Japan

kkang@brain.riken.jp haim@fiz.huji.ac.il

Estimating the amount of information within neuronal codes has been done by many researchers [1-4]. This is difficult to be done for spike time sequence unless there is large size of data [2] or time interval is very short [3] because the average over all possible spike sequence is hard to do. Here we develop an approximation, where all correlations between spike times are ignored except for two spikes occurring in succession. We study how Fisher information behaves in this case where inter-spike interval is Gamma distribution. To study the effect of statistical feature of inter-spike interval distribution on the efficiency of neuronal code, we fixed spontaneous firing rate of the spike sequence and calculate Fisher information as a function of Gamma parameter in the gamma function. We discuss how higher order approximation can be done and the importance of higher order correlations. 1. Rieke, F., Warland D., Steveninck R. R. and Bialek W. Spikes: Exploring the Neural Code. Cambridge : MIT Press. (1997) 2. SP Strong, R Koberle, RR de Ruyter van Steveninck & W Bialek, Phys Rev Lett 80, 197-200 (1998) 3. Panzeri S, Treves A, Schultz S, Rolls ET. Neural Comput. 11(7):1553 (1999) 4. J. Victor, Phys. Rev. E 66, 051903 (2002)

# A functional role of interaction between IT cortex and PF cortex in visual categorization task

Yoshiki Kashimori, Yu Ichinose, Kazuhisa Fujita Monday Poster –M49 University of Electro-Communications, Chofu, Tokyo, Japan kashi@pc.uec.ac.jp, makemale@yahoo.co.jp

The ability to group visual stimuli into meaningful categories is a fundamental cognitive processes. Some experiments have been made to investigate the neural mechanism of visual categorization. Freedman et al. reported that many PFC neurons responded selectively to the different types of visual stimuli belonging to either the cats or the dog category. Sigala and Logothetis recorded from inferior temporal cortex (ITC) after monkey learned a categorization task, and found that selectivity of the IT neurons was significantly increased to features critical for the task. Although some evidence is known that PFC and IT neurons sensitively respond in categorization task, little is known about the neural mechanism of categorization that gives the categorical information meaning. In order to study the neural mechanism of how the visual categorization is achieved based on the interaction between ITC and PFC areas, we propose a functional model of visual system in which categorization task is achieved based on functional roles of ITC and PFC. The functional role of ITC is to represent features of object parts, based on different resolution maps in early visual system such as V1 and V4. In ITC, visual stimuli are categorized by similarity of object features based on the features of object parts. The PFC neurons combine the information about feature and location of object parts, and generate a working memory of the object information relevant to the categorization task. The synaptic connections between ITC and PFC are learned so as to achieve the categorization task. The feedback signals from PFC to ITC enhance the sensitivity of ITC neurons that respond to the features of object parts relevant to the categorization task, and thereby causing an increase of feedforward signals to PFC. In the present study, we present a neural network model which makes categories of visual objects depending on categorization task. We investigated the neural mechanism of the categorization task of line drawings of faces used by Sigala and Logothetis. Using this model we show that ITC represents similarity of face images based on the information of the resolution maps in V1 and V4. We also show that PFC generates a working memory state, in which only the information of face features relevant to the task are sustained. It is further shown that the feedback connections from PFC to ITC may play an important role in extracting the diagnostic features of categorization task from visual images.

# Action potential backpropagation failure: All-or-none rescue by synaptic input in CA1 obliques

Matthew Kaufman Monday Poster –M35 Sridharan Devarajan, Justin Litchfield Stanford University Neuroscience, Stanford, California, USA <u>matt235@stanford.edu</u>, dsridhar@stanford.edu

Axo-somatic action potential backpropagation into dendritic arbors of CA1 pyramidal neurons plays an important role in generating synaptic plasticity at these dendrites. A recent numerical simulation study by Migliore et al (2005) on CA1 pyramidal neurons examined the role of KA channels in modulating backpropagation of APs into oblique dendrites. The study further found that spikes initiated in the dendrites do not effectively propagate into the soma. This functional isolation of the obliques from the rest of the neuron led the authors to speculate on channel distribution and local morphology as possible mechanisms for functional compartmentalization of the apical tree. The emerging picture in the field is that the neuron may be divided into functionally independent, isolable compartments, but the nature of what interactions exist among these functional modules (or the lack thereof) is not well understood. In the present study, we extend the model proposed in Migliore et al (2005) to examine rescue of failed BPAPs in oblique dendrites of CA1 pyramids. We performed computational simulations with NEURON using a novel stochastic dendrite generation algorithm to create egenerici neurons based on realistic morphological parameters for CA1 pyramidal dendrites. Our results demonstrate that appropriately timed local synaptic activity in the obliques is necessary and sufficient to cause all-or-none rescue of the backpropagating action potential from failure at a critical oblique branch point, mediating breakdown of the functional isolation of these oblique arbors. A critical threshold of synaptic input switches the nature of the response of the oblique dendrites from passive conduction to active backpropagation. We further argue that the all-or-none potentiation observed at individual CA1 synapses (Petersen et al. 1998) may be partly accounted for by the all-or-none rescue of entire oblique arbors upon local synaptic activity reaching rescue threshold. Results are discussed in the context of modeling the dynamics of interactions between the neuronal functional compartments.

# Spatiotemporal Phase Pattern Analysis of Alpha Desynchronization in Spontaneous Human EEG

Won Sup Kim Seung Kee Han Monday Poster -M104

Dept. of Physics, Chungbuk Nat'l Univ., Cheongju, South Korea

wskim@lorenz.chungbuk.ac.kr skhan@chungbuk.ac.kr

The amplitude of alpha rhythm in spontaneous human EEG is modulating in bursts with alternating high amplitude (synchronization) and low amplitude (desynchronization). It is observed that the low amplitude desynchronization events are accompanied by the phase singularities. To find out causal relation between the alpha desynchronization and the phase singularity from spatial phase map, we analyze the spatial phase patterns of the alpha desynchronization events at Cz using k-means clustering method. Several robust patterns are obtained independent of the assigned number of clusters. Among the patterns, the spiral patterns, the standing wave pattern, and traveling wave patterns are identified. For the two different types of spiral patterns, one rotating clockwise and the other count-clockwise, the center of spirals are located near the Cz. While for the standing wave pattern, the node line coincident with the central sulcus passes through the position of the Cz. From both examples, the phase singularities are connected with the geometrical structure of phase map, the core of the spiral pattern and the node of the standing wave pattern. It implies that the phase singularities are connected with the geometrical structure of phase map, the core of the spiral pattern and the node of the standing wave pattern. From this, we propose that the alpha desynchronization might come from the singularity in the global phase map.

### Formation of non-additive cortical object representations

Yihwa Kim Stefano Fusi, Walter Senn Tuesday Poster – T92

Department of Physiology, University of Bern, Bern, Switzerland kim@cns.unibe.ch, fusi@ini.unizh.ch

Since the early works of Lorente de No and Mountcastle roughly 50 years ago, neocortex is recognized as forming sheets of cortical columns, with each column representing a certain feature of an object. An object itself is classically believed to be represented by the combination of columns characterizing its features. Recent observations, however, have challenged this view of additive feature combinations. In fact, object representations in inferotemporal cortex (IT) may also be subtractive: adding a feature to the stimulus may suppress previously active columns rather than activate new ones [1]. We suggest a simple model of cortical column formation which emphasizes intracortical inhibition and which can account for these non-additive object representations. Inhibition is assumed to be mediated by a strong globally connected network, as it could be achieved through tight electrical couplings. The activation threshold and the gain of this global inhibitory population determine the width and the number of the cortical columns within the projection domain of the global inhibition. Because inhibition is assumed to be recurrently connected to all excitatory neurons within the cortical area, the overall activity level is normalized and therefore independent of the stimulus intensity and the number of features defining an object. The non-additive object representation is a consequence of this normalizing competition provided by the global inhibition. Besides global inhibition, two key features are enabling column formation: (1) Hebbian plasticity among the feedforward and recurrent synaptic weights, and (2) homeostatic plasticity at the excitatory neurons. While Hebbian plasticity wires co-active neurons together and hence reinforces any local dominance of an object representation, homeostatic plasticity provides the necessary long-term competition for a fair allocation of cortical resources. Different forms of homeostatic processes may subserve column formation, e.g. an adaptive change of excitability or an adaptive change of the synaptic strengths [2]. However, unlike the homeostatic mechanisms observed in [2], the time constant of our homeostatic process at the critical moment of the cortical symmetry breaking must be in the same order of magnitude as the time constant of the Hebbian modifications. We therefore postulate a homeostatic process which shares the time constant of the Hebbian modifications around the LTP/LTD equilibrium point, i.e. when the postsynaptic calcium concentration is at some intermediate level. [1] Tsunoda K., Yamane, Y., Nishizaki M., Tanifuji M., 2001, Nature Neuroscience, 4(8), 832-838 [2] Turrigiano G., Nelson S., 2004, Nature Reviews Neuroscience, 5, 97-107

Development of a mechanistic model for explain responses of X-cells in the LGN	ing the variation in	Fast, flexible and adaptive motor control achieved learning with recruitment	l by pairing neuronal
Floortje Klijn Mike Denham	Monday Poster –M52	Christoph Kolodziejski Bernd Porr Florentin Woergoetter	Sunday Poster –S84
University of Plymouth, CTCN, Plymouth, Devon	UK	BCCN, University of Goettingen, Goettingen, Germa	any
floortje.klijn@plymouth.ac.uk, m.denham@plymo	uth.ac.uk		iiiy
Development of a mechanistic model for explainin X-cells in the lateral geniculate nucleus of cats Flo CTCN, University of Plymouth The lateral genicul main gateway of visual information from the retina predict and understand the spatiotemporal features s in the cortex, a complete understanding and model thalamocortical relay cells of the LGN are needed. been developed to simulate and predict the LGN cd selectivity on basis of different response variables, latency. It is not clear, however, whether the featur completely represented in the response variables un features of a stimulus are also represented in the te activity. Furthermore, LGN cells show a wide vari the response in time, for example in the shape, leve response. An open question is what is the cause of mechanistic model of the LGN is being developed model investigates to what extent the spatiotempor ganglion cells can explain the variation in response Furthermore, it investigates to what extent the prop coupling between retinal ganglion cells, relay cells can cause variation in responses of LGN relay cell dynamics of neurons in the primary visual cortex ( nucleus (TRN) and parabrachial region (PBR) are on, together with their physiological couplings wit insight into the emergence of this variation in response its function.	ortje Klijn and Mike Denham late nucleus (LGN) is the to the cortex. To be able to belectivity properties of cells of these properties in the Several models of LGN have ellsi spatiotemporal feature like firing rate and response e selectivity of the LGN is sed. Studies show that special mporal pattern of spike ation in the development of el and length of their sustained this variation in responses. A to address this question. The al dynamics of retinal es of LGN relay cells. berties of the physiological and inhibitory interneurons s. The spatiotemporal V1), thalamic reticular included in the model later h the LGN. It is expected that	The motor system must be able to adapt quickly to load changes. In addition is known that also long-term learning exists in the motor system, which, for example, allows us to learn difficult motor skills like playing the piano or excelling in sports. It is generally agreed that many times motor learning oct through the generation of forward models for an originally existing control I Hence, early on, the system cumbersomely executes a motor action under the closed-loop feedback control, whereas later, after some successful learning, forward model has been generated and the system executes a much improve motion sequence "without thinking". In this study we show that it is possible combine temporal sequence learning with recruitment to learn a forward mod of a reflex and to execute it with the momentarily required strength, which depends on the load. To this end we employ a learning rule, which we had recently introduced (Porr and Woergoetter Neural Comp. 15, 831-864, 2003 and which is similar to spike timing-dependent plasticity. Using this rule, at one-arm joint we correlate an earlier disturbance loading force with the measured position change that this force induces. Without learning, the posi change is originally compensated with some delay by a reflex like feedback reaction. After learning the system reacts immediately to the loading pulse a produces the required counterforce to keep the arm position stable. This won for constant loads. It is, however, possible to add a simple recruitment mechanism to this and now the system can learn compensating also differen	
A cell assembly based model for the cortical mic	erocircuitry		
Andreas Knoblauch Rüdiger Kupper, Marc-Oliver Gewaltig, Ursula Ko	<i>Tuesday Poster – T66</i> berner, Edgar Koerner	Pheromone plumes provide optimal signal for the	olfactory sensory neuron
Honda Research Institute Europe, Offenbach/Main andreas.knoblauch@honda-ri.de, ruediger.kupper@		Lubomir Kostal Petr Lansky Jean-Pierre Rospars	Monday Poster –M86
In this work we present first simulation results sub proposed conceptual model of computation in neod et al., Neural Networks 12:989-1005, 1999). This functional interpretation of the six-layered column related subcortical (thalamic) structures. It hypothe interacting processing systems at each stage of the system (middle cortical layers IV and lower III) ac processing where the first spike wave traveling up activate a coarse initial hypothesis at each level. I	cortical architecture (Korner model gives a detailed ar cortical architecture and esizes three different but cortical hierarchy: The A- ecomplishes fast bottom-up the cortical hierarchy can	Prague, Czech Republic kostal@biomed.cas.cz lansky@biomed.cas.cz Orientation towards food and mate, especially in inse controlled behavior which relies on the detection of o from the source. The atmospheric turbulence causes	odorant molecules delivered
activate a coarse initial hypothesis at each level. I		areates a wide scale of temporal variations in the ada	

layers II and upper III) the initial hypothesis is refined by slower iterative processes involving horizontal and vertical exchange of information. Finally, the C-system (deep layers V and VI) represents the local hypothesis of a macrocolumn which is fed back to the B-system of a lower level inducing expectations and predictions for the present and future input signals. Predicted input signals are suppressed at an early cortical stage, and only differences between predicted and actual signals can reach the next higher level. Learning of new representations is induced if the difference signal is too large and if the difference signal reaches the highest level of cortical integration, the hippocampus. These ideas are illustrated by an example implementation of the microcircuitry in a single cortical macrocolumn based on cell assemblies and associative memories. In a second step we have integrated our model at the level of V4 into a large scale implementation of the visual system involving several primary and higher visual cortical areas as well as parts of the hippocampal formation, and subcortical structures involved in generating eye saccades. With this model we can demonstrate object classification and the learning of new object representations.

creates a wide scale of temporal variations in the odorant concentration. These stochastic variations in the structure of natural odorant signals were shown to be essential for the insect to locate the source of the stimulus. Nevertheless, the maximal temporal resolution and input range of the olfactory neuron is limited by both physical and biochemical reasons. The detailed analysis of the signal processing performed by the neuron thus provides insight on the performance and adaptation of the sensory system to the natural conditions. In this work we study the perireceptor and receptor events in the model of single olfactory receptor neuron of the male moth Antheraea polyphemus. This first stage of signal transduction imposes limiting condition on the amount of information the olfactory neuron can process. By employing basic concepts of information theory we predict such stimulus characteristics that enable the system to perform optimally -- to maximize the information transmission. The results are given in terms of stimulus distributions and intermittency factors which enables us to make a comparison with experimental measurements of odorant plume structure in natural conditions. We conclude that the optimal stimulus is described by exponential probability density function which is in agreement with the experiments and that the predicted intermittency factors fall within observed ranges.

# Population synchrony generation in a layered network of the cat visual cortex

Jens Kremkow	Tuesday Poster – T69
Arvind Kumar, Stefan Rotter, Ad Aertsen	
Neurobiology and Biophysic, INCM(UMR6193)/CNRS	S, Freiburg, Germany
kremkow@biologie.uni-freiburg.de, kumar@biologie.u	ni-freiburg.de

Recently a quantitative wiring diagram of the local neuronal network of cat visual cortex was described (Binzegger et al. 2004), which gives the first realistic estimate of synaptic connections among various neuron types in different cortical layers. Here we numerically studied the dynamics of the resulting heterogeneous layered network of leaky-integrate-fire neurons, connected with conductance-based synapses. Binzegger et al (2004) specified the total number of neurons in cat area 17 to be ~  $31x10^{6}$ . We downscaled the network of area 17 of cat to a size of 10,000 or 50,000 neurons such that the proportion of neurons and the ratio of excitatory (NE) and inhibitory (NI) neurons across the layers were conserved. The number of synapses within a layer was restricted to have a maximum sparsity p=10%, (p=K/N\*100, K is the number of synapses each neuron receives and N is the number of neurons). The layered network elicited an interesting asynchronous activity intermitted by population wide synchronizations, among other states. These population bursts [PB] were initiated by a network hot spot and spread into the whole network. The cause of this PB is the correlation amplifying nature of the recurrent network, which becomes significant in densely coupled network. The layer of origin was dependent on the level of excitatory recurrent connections, which was highest in layer 2/3. PBs occurred for all the network sizes studied (up to 50,000), excluding the possibility that a PB occurs because the correlation originated due to shared presynaptic pools. However, the characteristics of the PBs (e.g. the probability of their occurrence) were susceptible to changes in the network architecture. So we conclude that in a heterogeneous structured network, the region with highest degree of recurrence and high out-degree may become a hot-spot to initiate a population wide synchronization. Binzegger, T., Douglas, R. J., & Martin, K. A. C. (2004). A quantitative map of the circuit of the cat primary visual cortex. {J. Neurosci.} 39 (24), 8441-8453

# Effects of multiple spike-initiation zones on signal integration properties of leech touch cells

Jutta Kretzberg Monday Poster –M23 Friedrich Kretschmer, Antonia Marin-Burgin University of Oldenburg, IBU, Oldenburg, Germany jutta.kretzberg@uni-oldenburg.de, friedrich.kretschmer@mail.uni-oldenburg.de

Information processing is not for all neurons consistent with the classical picture of a neuron that transforms integrated input signal to sequences of action potentials at the axon hilloc. Particularly in sensory cells and in invertebrate neurons, spikes can be generated far away from the soma. Several neuronal types were found to have multiple spike-initiation zones. Moreover, the site of spike initiation can vary depending on neuronal excitation. These findings can have severe impacts on neuronal information processing. The aim of this combined experimental and modeling study is to analyze the effects of multiple spike-initiation zones in T-cells (touch sensors) of the leech. The soma of these mechanosensory neurons is located in a ganglion of the central nervous system, while the touch sensitive dendritic endings are located in the skin. Based on experimental results, Burgin & Szczupak (2003) proposed that leech T-cells have two separate spike initiation zones, a peripheral one to signal touch stimuli and a central one to respond to synaptic input within the ganglion. To test this hypothesis, we implemented a compartmental model of a leech T-cell in NEURON, using modified versions of the cell morphology shown by Cataldo et al. (2005) and Hodgkin-Huxley type conductances developed by Baccus (1998). This model reproduces the experimental finding that spike responses to somatic current injection cease during inhibitory synaptic input, while responses to skin stimulation are not altered. Comparing a model with homogeneous channel distribution and a model with separate spike initiation zones for peripheral and central information processing, we found that both models show this effect. Hence, the experimentally observed difference in the integration of inputs could be explained by the electric isolation of spatially distant parts of the cell. By specifically analyzing 1. How does the spatial distribution of active zones influence the integration of central and peripheral inputs? 2. How is information processing influenced by the ratio of the maximum conductances in strongly active and weakly active regions of the cell? 3. Does the site of spike initiation vary depending on the level of excitation? 4. Can the location of the inhibitory synapse be predicted? we hope to find universal principles of neuronal information processing, showing how inputs interact and influence the final output of a neuron. References: Burgin & Szczupak (2003) J Comp Physiol A 189:59-67. Cataldo et al. (2005) J Computat Neurosci 18:5-24. Baccus (1998) Proc. Natl. Acad. Sci. USA 95:8345-8350.

#### Coherence resonance due to correlated noise in neuronal models

Thomas Kreuz Stefano Luccioli Alessandro Torcini Sunday Poster - S77

Istituto dei sistemi complessi - CNR, Sesto Fiorentino, Italy

kreuz@ino.it luccioli@inoa.it

We study the regularity of noise-induced excitations in the FitzHugh-Nagumo (FHN) neuronal model subject to excitatory and inhibitory high-frequency input with and without correlations. For each value of the correlation a relative maximum of spike coherence can be observed for intermediate noise strengths. Moreover, the FHN system exhibits an absolute maximum of coherent spiking for intermediate values of both, the noise amplitude and the strength of correlation (Double Coherence Resonance). The underlying mechanisms can be explained by means of the discrete input statistics.

#### Dale's principle and the formation of spatio-temporal activity patterns

Birgit Kriener Ad Aertsen Stefan Rotter Tuesday Poster –T37

BCCN Freiburg (Germany), Albert-Ludwigs-University Freiburg (Germany) Freiburg, Germany

kriener@biologie.uni-freiburg.de aertsen@biologie.uni-freiburg.de

Cortical networks are assumed to respect Dale's principle, according to which neurons are either inhibitory or excitatory for all their synaptic projections. Here we demonstrate the crucial impact of Dale's principle on the ongoing activity dynamics in networks of different topologies, ranging from regular and 'smallworld' to random coupling topologies in 1- and 2-dimensional space. We find that in simulated networks of integrate-and-fire neurons, which do not regard Dale's principle the inhibition dominated regime is nearly independent of the underlying network topology, while Dale-conform networks show a broad range of synchronization phenomena and formation of spatio-temporal activity patterns (e.g. 'activity bumps') according to their respective coupling scheme.

#### Dynamics of latching in Potts models of large scale cortical networks

Emilio Kropff Alessandro Treves Tuesday Poster -T72

SISSA, Trieste, Italy kropff@sissa.it, ale@sissa.it

Multi-modular Potts networks have been introduced as simplified models of large scale cortical networks that store and retrieve semantic memories. We study a version of these networks which includes two important ingredients: neural adaptation and correlation in the stored patterns. It has been shown that under these conditions Potts networks present latching: the capacity to hop spontaneously from one attractor state to another following a structured set of complex transition probabilities. Latching is a mechanism for recursion, and thus a candidate to explain the emergence of language in human beings, following the proposal by Chomsky et al, 2002. We develop the mean field equations that govern the dynamics of latching for networks storing 1 and 2 global patterns. This is enough to study ënoiselessí latching, which we show to be the result of a finite-size effect for low levels of correlation. Only for very high correlation between patterns the numerical solutions of the dynamical equations have a latching behavior. Important parameters that govern dynamics (other than the size of the network) are the threshold U, mimicking a global inhibition system, and the self-weight of Potts units J, accounting for the capacity of local networks to sustain their activity within a given basin of attraction. An equilibrium between these parameters is necessary for latching, while small variations of U can control the complexity of latching transitions for a given set of correlated patterns, spanning all the range from completely random to deterministic, and including the intermediate -- rich in complexity -case.

Fully Optimized Discrimination of Physiological Responses to Auditory Stimuli	A mechanism for NMDA-activated high-frequency firing in midbrain dopaminergic neurons.	
Stepan Kruglikov Monday Poster – M98 Sharmila Chari Paul Rapp	Alexey Kuznetsov     Monday AM Oral       Nancy Kopell, Charles Wilson	
Steven Weinstein Barbara Given Steven Schiff	Department of Mathematical Sciences, IUPUI, Indianapolis, Indiana, USA <u>alexey@math.iupui.edu</u> , nk@bu.edu	
George Mason University, Fairfax, Virginia, USA	Mesencephalic dopamine neurons ordinarily will not fire faster than about 10/s in response to somatic current injections. However, in response to dendritic excitation, much higher rates are briefly attained. In an analysis of a simplified	
skruglikov@rmgroup.com, schari@gmu.edu The use of multivariate measurements to characterize brain activity (electrical, magnetic, optical) is widespread. The most common approaches to reduce the complexity of such observations include principal and independent component analysis (PCA and ICA), which are not well suited for discrimination tasks. Here we study the neurophysiological responses to tones, phonemes, and artificially generated elongated phonemes, and their physiological responses in normal children. We employed fully optimized linear discrimination analysis to maximally separate the multi-electrode responses to tones and phonemes, and classified the response to elongated phonemes. We find that discrimination between tones and phonemes is dependent upon responses from associative regions of the brain quite distinct from the primary sensory cortices typically emphasized by PCA or ICA. Our approach is made feasible by the increase in computational power of ordinary personal computers, and has significant advantages for a wide range of neuronal imaging modalities.	biophysical model, we suggest a way such high-frequency transient firing may be evoked. Our model represents the neuron as a number of electrically coupled compartments with different natural frequencies, which correspond to the soma and parts of the dendrite. We reduce this model, substituting all the diversity of the compartments that describes real dendritic geometry by a pair of compartments: the slowest, somatic and the fastest, the most distal dendritic one. We have shown that, in the absence of any synaptic stimulation, oscillatory pattern in this model is controlled by the somatic compartment, and, therefore, has a very low frequency. We consider and compare NMDA and AMPA activation applied to the dendritic compartment. Our main result is that activation of the dendritic NMDA receptors evokes oscillations at a much higher frequency. We have also shown that dendritic AMPA activation, by contrast, cannot increase the frequency significantly. We show that the elevated frequency emerges due to the domination by the dendritic compartment during the application of NMDA. We employ a phenomenon of localization to explain this behaviour.	
	Modeling of dopamine D4 receptor-induced regulation of cortical activity	
Simulations of signal flow in a functional model of the cortical column	Anna Kuznetsova Sunday Poster – S5 Richard Deth	
Rüdiger Kupper Sunday Poster –S25 Andreas Knoblauch Marc-Oliver Gewaltig Ursula Koerner Edgar Koerner Honda Research Institute Europe GmbH, Offenbach/Main, Germany	The Department of Mathematical Sciences, IUPUI Indianapolis, Indiana, USA anna@math.iupui.edu r.deth@neu.edu	
ruediger.kupper@honda-ri.de, andreas.knoblauch@honda-ri.de	Studies in humans have demonstrated the ability of dopamine to promote	
We present simulations of a cortical column prototype substantiating a previously proposed model of computation in neocortical architecture (Koerner et al., Neural Networks 12:989-1005, 1999). It bridges the gap between cortical processing of signals at the single-neuron level, and the processing of cognitive symbols at the level of knowledge representation. The same columnar circuit is re-used all over the cortex, applying a generic algorithm to varying sensory data. This model gives a detailed functional interpretation of the six-layered columnar cortical architecture. The "A-system" (cortical layers IV and lower III) accomplishes fast bottom-up processing. It activates a coarse but fast initial "local hypothesis" on the stimulus. In the "B-system" (layers II and upper III), this initial hypothesis is refined by iterative exchange of information between columns. Finally, the "C-system" (layers V and VI) represents the local	increased gamma frequency oscillatory activity in conjunction with improved synchrony between brain regions. Episodes of attention are associated with increased gamma oscillations in neuronal firing involving multiple brain regions. D4 dopamine receptors are intimately involved in attention, and a significant reduction in the intensity of attention-related gamma oscillations is observed with drugs that block D4-type dopamine receptors. D4 receptors have the unique ability to carry out phospholipid methylation (PLM), in which the insertion of methyl groups increases the spacing between membrane phospholipids. D4Rs play an important role in neuropsychiatric disorders involving working memory deficits (schizophrenia and ADHD). Regular spiking principal neurons are able to produce a self-terminating spike trains related to short-term memory function under neuromodulatory control. In a cortical network, we have explored an influence of DA modulation on bursting activity	
interpretation of the input signals that results from the local integration of bottom-up, lateral, and top-down signals. It is fed back to the B-system of a lower level, inducing revised interpretations of the input signals at this stage. Subsequently, input signals that match the local prediction are suppressed, and only differences between predicted and actual signals can reach the next higher cortical level. Thus, stimulus content is effectively expressed in terms of previously achieved knowledge (self-reference). We simulate the signal flow in the A- and B-systems of a set of model columns across three hierarchical cortical areas. In this reduced (but instructive) simulation, we implement word recognition from a string of characters. Focusing on the intra- and inter-columnar dynamics, we show how the different processing subsystems interact in order to switch off expected signals and accomplish symbolic recognition of words, and how representations for new words can be constructed based on old representations. It is a major lesson to be learned from this prototype model,	and properties of evoked spike trains. We have demonstrated that the proposed mechanism of D4R-induced PLM can mediate spike trains and modulate its duration and rate. D4R knockout mouse model has different behavioral characteristics that are believed to be indicative of changes in such brain areas as striatum, nucleus accumbens (NAc), and prefrontal cortex (PFC). All these areas are known to be smaller in brains of human ADHD patients. The principal cortical-subcortical neural network for model of schizophrenia has also PFC and NAc/Striatum components. In this work, we have utilized model of a simple cortical neuronal network to explore how DA-induced increase of membrane fluidity would affect neuronal firing rates and network oscillations in a manner that promotes gamma frequency oscillatory behavior and modulates bursting activity. Then we have studied how the proposed mechanism of DA regulation can affect transmission in a simple cortical-subcortical neural network model exhibits gamma synchronization and spike	
that a stable pattern of activation in the columnar subsystems is almost never reached, and that this is not a limitation, but a meaningful state of the system.	train variation upon DA modulation. This can contribute to the modulation of cortical activity (attention, working memory). Connectivity within the network	

that a stable pattern of activation in the columnar subsystems is almost never reached, and that this is not a limitation, but a meaningful state of the system. Iteration of activation patterns in limit cycles is the rule. We see this as a strong hint, that the typical, neurophysiologically observed cortical oscillations represent a natural mode of processing in the cortex, and are inherent from the unique kind of information flow inside and between columns. This columnar dynamics is the basis to learning and understanding.

also been documented.

influence the effect of DA, and dysfunctional PLM can lead to impaired neural

mental diseases (e.g. autism and schizophrenia), where impaired methylation has

synchronization. Results of this study should have significance for our understanding of abnormal synchronization for patients suffering from different

Spike alignment in bursting neurons	Monday Poster –M95	Reaction to neural signatures through excitatory synapses in Central Pattern Generators models	
Luis Lago-Fernandez		Roberto Latorre <i>Monday Posters –</i> Francisco de Borja RodrÌguez	-M60
Universidad AutÛnoma de Madrid, Madrid, Spain luis.lago@uam.es		Pablo Varona	
•	tion encoding used by	GNB. EPS. Universidad AutÛnoma de Madrid, Madrid, Spain	
Bursting activity is a common mechanism of information encoding used by many different types of neurons. It is characterized by periods of high frequency spiking (bursts) followed by periods with no spiking activity. It has been discussed that bursts could be the best kind of stimuli for exciting a cell, since neurons only rarely respond to single spikes. Recently, the presence of very precise intra-burst firing patterns has been reported in bursting neurons of the pyloric network of the lobster stomatogastric nervous system. These patterns, which have been called neural signatures, are cell-specific and depend on the synaptic connectivity of the network. Although they have not been assigned any functional roles, it has been shown that the response of the network is highly dependent on the specific signatures, which suggests that intra-burst activity can be essential in neural transmission. Typical analysis of intra-burst activity uses the first spike in the burst as the time reference, and computes ISI distributions and return maps to characterize the neural signatures. In this paper we show that the first spike may not be the best time reference, and propose a new method to		roberto.latorre@uam.es f.rodriguez@uam.es The activity of central pattern generator (CPG) neurons is processed by se different readers: neurons within the same CPG, neurons in other intercom CPGs and muscles. Taking this into account, it is not surprising that CPG neurons may use diÆerent codes in their activity. In this paper we study th capability of a CPG model to react to neural signatures through excitatory synapses. Neural signatures are cell-specific interspike interval distribution within their spiking-bursting activity. These fingerprints are encoded in th activity of the cells in addition to the information provided by their slow w rhythm and phase relationships. The results shown in this paper suggest th neural signatures can be a mechanism to induce fast changes in the proper the rhythm generated by a CPG	nected he ns e vave nat
align the bursts that minimizes the overlap among the the different spikes in the burst.		Importance of electrophysiological signal features assessed by classific trees	cation
Gatsby Computational Neuroscience Unit University College London, London, UK pel@gatsby.ucl.ac.uk Arnd.roth@ucl.ac.uk A major open question in neuroscience is: "what's the neural code?". The standard approach to answering this, pioneered by Richmond and Optican almost two decades ago [1], is to record spike trains and compute information under different coding models. Unfortunately, this approach requires huge amounts of data and thus, despite considerable efforts and some success, it is still not clear to what extent the neural code, in mammalian cortex, relies on precise spike timing, and in particular on spike patterns. An alternative approach follows from the observation that if spike patterns are to	Andreea Lazar Sunday Poster –S Raul Muresan Ellen Stadtler Matthias Munk Gordon Pipa FIGSS, Coneural, Frankfurt am Main, Germany andreealazar@yahoo.com raulmuresan@yahoo.com Activity in prefrontal cortex is considered to maintain, abstract representat of previously perceived objects. In order to investigate the neuronal mecha involved in this process, signals were recorded in ventral prefrontal cortex monkeys performing a short time memory task. We have used the Gini inc and Shanonis entropy measurements, in the context of classification trees, identify the most relevant features of the recorded signals. Results show th data mining approaches bring some precious insights in the complex dyna of the cortex. <b>Dynamics and robustness of recurrent spiking networks</b> Andreea Lazar <i>Tuesday Poster –1</i> Gordon Pipa, Jochen Triesch FIGSS, Coneural, Frankfurt am Main, Germany andreealazar@yahoo.com, pipa@mpih-frankfurt.mpg.de In this study, we investigated recurrent neuronal networks and how neuror dynamics and its robustness to perturbations are shaped by neuronal plasti that operates on various time scales. We consider two such mechanisms fc plasticity. The first, spike timing dependent plasticity ('STDP'), has receiv much attention in the recent years. It had been demonstrated that STDP ca used for the learning of spike sequences and that it closely corresponds to correlation analysis, which is an established system identification method, is because, spike-timing-dependent learning minimizes the errors between actually occurring outputs and the output spikes predicted by the pre-synaj spikes. The second type of plasticity that we considered in this study is the intrinsic plasticity (IP) mechanism that changes the intrinsic excitability of neuron. In particular, it was shown that the two forms of plasticity matures on spike sequences in the town of plasticity matures on spike sequences in the town of plasticity matures on spikes in the second the system identification method.	tions anisms a of dex to nat mics <i>T93</i> nal icity or ed in be . This the ptic	
		synergistically interact to allow the discovery of heavy-tailed directions in input. Since both types seem to be ubiquitous phenomena in the brain, we interested in how both may interact to shape the dynamics of recurrent net We considered a simple model of a recurrent spiking neural network that combines STDP and IP. To characterize the networkis ability to process information reliably we assessed the robustness of its activity by perturbin individual states.	are works.

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Information Representation with an Ensemble of Hodgkin-Huxley	Neurons Cross-scale Neurodynamical Odour C	Coding and Its Modulation
Aurel Lazar Monday Poster		Monday Poster – M87
	Yuqiao Gu	
Columbia University, New York, New York, USA	Jean-Pierre Rospars	
	Sylvia Anton	
aurel@ee.columbia.edu		
W	SLU, Agora for Biosystems, Uppsala, S	Sweden
We investigate the representation of a bandlimited stimulus by an ensen Hodgkin-Huxley neurons with multiplicative coupling. We show that su		
ensemble is I/O equivalent to an ensemble of integrate-and-fire neurons		
variable thresholds. We describe a general algorithm for recovering the		
at the input of the neuronal ensemble and demonstrate how to implement		d noisy signals, which in insects are
recovery algorithm using NeuroHardware primitives.	processed in the antennal lobe (AL), the	
		meruli. All synaptic contacts between the
	three main types of AL neurons (olfacto	
	inhibitory neurons, LN, and projection r	
Criticality of Avalanche Dynamics in Adaptive Recurrent Networks	glomeruli. There are global fast synaptic	c inhibitory contacts from LNs to PNs,
	no synaptic contacts between PNs and s	
Anna Levina Tuesday Poster		
Udo Ernst	innervate several glomeruli. Electrophys	
Michael Herrmann	demonstrated that, when the antenna is j	
	may oscillate synchronously, and simult	
Goettingen University, Goettingen, Germany	synchronized, subthreshold oscillations	
	Hodgkin-Huxley type models of the var	
anna@chaos.gwdg.de udo@neuro.uni-bremen.de	and LNs were proposed. Utilizing these knowledge on glomerular morphology,	
udo@neuro.um-bremen.de	the encoding of odorant signals, we have	
Neural networks with long-range connectivity are known to display criti		
behavior including power-law activity fluctuations. It has been shown ea		
the authors that precisely specified connections strengths are sufficient t		
produce this behavior. The predictions of the model have been observed		
experimentally both in neural cultures and in slices. In a more realistic n		
which includes synaptic dynamics on short time scales, the system regul		
itself to the critical point. In the present contribution we proceed a further		
by imposing a slow adaptive dynamics to the network which achieves cr		
by a learning process. The learning rule is presented on a firm mathematic		rally related odour coding problems. By
basis within the theory of branching processes, which have have been us		he transient potassium current, as well as
similar contexts as an approximation of the true systems dynamics. Brar		
processes are Markovian, i.e. may be appropriate for feed-forward network		ex pheromones. We also investigate how
model only how many neurons are active at a time. For instance, these is processes have been used to model threshold systems with recurrent corr		ant ouours.
and which exhibit correlations even without affecting a threshold crossin		
target of the connection. We prove the asymptotic equivalence between	Is the superposition of many independent	dent snike trains a Poisson process?
avalanches in the dynamics of globally connected networks of spiking n		active spine trains a roisson process:
and avalanches generated by a Galton-Watson branching process. We us		Sunday Poster – S64
established equivalence to explain why the critical exponent assumes the		Summy Poster BOT

Max-Planck Institute PKS Dresden, Dresden, Germany

benji@mpipks-dresden.mpg.de

We study the sum of many independent spike trains and ask whether the resulting spike train has Poisson statistics or not \cite{Lin06}. It is shown that for a non-Poissonian statistics of the single spike train, the resulting sum of spikes has exponential interspike interval (ISI) distribution, vanishing ISI correlation at finite lag but exhibits exactly the same power spectrum as the original spike train does. This paradox is resolved by considering what happens to ISI correlations in the limit of infinite number of superposed trains. Implications of our findings for stochastic models in the neurosciences are briefly discussed.

University of Virginia, Department of Neurosurgery Charlottesville, Virginia, USA

wbl@virginia.edu hocking@virginia.edu

numerical simulations.

**Hippocampal Model** 

William Levy

Ashlie Hocking

Introducing theta-modulated input into a minimal model of the CA3 region of the hippocampus has significant effects on gamma oscillations. In the absence of theta-modulated input, the gamma oscillations are robust across a range of parameters. Introducing theta-modulated input weakens the gamma oscillations to a power more consistent with power spectra acquired from laboratory animals. With these changes, the hippocampal model is able to reproduce hippocampal behavior from a wide variety of measures: power spectra, neuronal membrane potential traces, and cognitive behavior.

3/2 and how it results from specific coupling strengths. In the present case we

are able to ensure rigorously the validity of the approximation of the network dynamics by a branching process such that the learning rule is automatically

eligible for the purpose of guiding the neural network towards the edge of criticality. The theoretically predicted behavior is confirmed in all aspects by

Theta-Modulated Input Reduces Intrinsic Gamma Oscillations in a

Tuesday Poster -T13

Activation of cholinergic receptors in the olfactory bulb modulates odor discrimination

Christiane Linster Daniel Rubin Nathalie Mandairon Casara Ferretti Conor Stack Thomas Cleland

Cornell University, Ithaca, New York, USA

cl243@cornell.edu dbr25@cornell.edu

We present a detailed biophysical model of the mammalian olfactory bulb glomerular network designed to investigate how cholinergic inputs modulate olfactory discrimination. We first show that local blockade of nicotinic, but not muscarinic receptors in the olfactory bulb of rats decreases the perceptual discrimination between pairs of chemically similar odorants, whereas activation of cholinergic receptors in the olfactory bulb improves discrimination. We then use a model of olfactory bulb glomerular computation to show how the known cellular effects of nicotinic receptor activation mediate these behavioral observations. Experimentally-observed responses to a homologous series of odorants (unbranched aliphatic aldehydes) were simulated; realistic cholinergic inputs to the olfactory bulb model, acting on nicotinic receptors in the glomerular layer, acted to increase the discriminability of the bulbar responses generated to very similar odorants. This simulation predicted, correctly, that blockade of nicotinic receptors in the olfactory bulb would result in decreased discrimination capabilities in animals, whereas increased activation of nicotinic receptors would result in enhanced discrimination capabilities.

### Ih supports place field formation in a model of the cortical pathway to CA1

Kit Longden

Tuesday Poster - T8

Sunday Poster -S82

Imperial College London, London, UK

kit@anc.ed.ac.uk

The distal dendrites of CA1 pyramidal cells have characteristically high densities of the hyperpolarisation-activated cation current Ih and these dendrites are the targets of cortical input to CA1. Blocking Ih increases the membrane time constant and increases the membrane resistance in these dendrites. It has therefore been proposed that Ih facilitates the propagation of synchronous cortical inputs to CA1. Using a conductance-based integrate-and-fire model of the cortical pathway to CA1, we show that Ih facilitates place field formation in this pathway in response to increases in asynchronous cortical input rates. This occurs because the effects of Ih are equivalent to a constant inhibitory conductance, and when the time scale of feedforward inhibition is more rapid than the time scales of the AMPA postsynaptic potentials. It is proposed that the pathway can support rate coding through NMDA mediated postsynaptic potentials in the absence of CA3 input as shown here, and also the propagation of synchronous AMPA mediated postsynaptic potentials in the presence of suitable CA3 input as investigated in other studies.

# Two-phase comparator model of the entorhinal cortex -- hippocampal loop forms realistic activity map

Andras Lorincz Takacs Balint Tuesday Poster -T11

Eotvos Lorand University, Budapest, Hungary

andras.lorincz@elte.hu takbal@elte.hu

The reconstruction network model of the entorhinal cortex -- hippocampal (EC-HC) loop was studied by using realistic robot simulations in a U-shaped labyrinth. We started from inputs similar to those found in the postrhinal cortex and developed neural responses dictated by the model for the superficial and deep layers of the EC as well as for the CA1 subfield. Good agreement between simulations and experiments was found.

### Simple conditions for forming triangular grids

Andras Lorincz, Takacs Balint Eotvos Lorand University, Budapest, Hungary <u>andras.lorincz@elte.hu</u>, takbal@elte.hu

We have studied simple learning rules to see how firing maps containing triangular grids -- as found inin vivo experiments -- can be developed by Hebbian-like learning rules in realistic robotic simulations. We have found that anti-Hebbian learning is capable of developing triangular grids provided that (i) the input is invariant to egocentric rotation and (ii) the weight decreasing effect of the anti-Hebbian rule is counteracted. We have examined different possibilities and found that maximization of bottom-up maximization of information transfer spares the triangular grid formation, whereas whitening does not.

Tuesday Poster –T12

# Model-based Comparison of the Passive Electrical Properties of Three Species of Purkinje Cells

Huo Lu Sunday Poster –S29 Hugo Cornelis, Buky Aworinde, David Senseman, James Bower Research Imaging Center, UTHSCSA, San Antonio, Texas, USA <u>luh0@uthscsa.edu</u>, hugo.cornelis@gmail.com

Arguably one of the most complex neurons in the brain, the last 10 years have seen a considerable and growing interest in constructing realistic compartmental models of the cerebellar Purkinje cell (PC). These models have been used to make a number of unusual but important predictions regarding the active electrical properties of this cell's large dendrite and the effect of those intrinsic properties on its processing of a correspondingly large number of synaptic inputs (De Schutter and Bower, 1994a, b, c; Gundappa-Sulur et al., 1999; Santamaria et al., 2002). Most of this work to date, however, has been based on the Guinea Pig reconstruction of Rapp et al. (1994). The goal of the effort described here is to compare and contrast the computational consequences of the dendritic morphology of three species of PCs: one from a reptile, the turtle Pseudemys scripta, and two from mammals (the laboratory rat and the Guinea Pig). We first examined differences and similarities in dendritic branching patterns after three-dimensional anatomical reconstruction. In all three dendrites, the most common dendritic segment had a diameter of 1 micron. The spatial distribution of branch lengths, however, was found to differ between the mammalian and reptilian PCs with distribution shifted towards smaller dendritic diameters with two peaks in the turtle PC. These anatomical reconstructions then provided a basis for comparing the expected passive properties of each type of dendrite. In particular, we compared the effects of current injection on somatic responses. The results reveal anatomically related differences in dendritic effects of the soma for very small and large dendrites, but very similar effects for the 1 micron diameter dendrites prominent in all three species of PCs. These initial modeling efforts will form the basis for further modeling and experimental studies examining the active properties of each dendrite in an effort to determine if PCs in these different species share common computational properties.

Effects of Stress & Genotype on Meta-parameter Dynamics in a Simple Reinforcement Learning Model	Olfactory Perception: Correlating Phylogenetic and Psychophysical Information	
Gediminas LuksysSunday Poster –580Carmen Sandi,Wulfram GerstnerEcole Polytechn. Federale de Lausanne (EPFL), Lausanne, Switzerlandgediminas.luksys@epfl.ch, carmen.sandi@epfl.ch	Amir Madany Mamlouk Monday Poster – M77 Elena Schuh Thomas Martinetz	
Animals (and humans) choose their actions based on learned reward predictions for different environmental stimuli and motivational drives toward specific rewards. Different aspects of learning are known to be influenced by stress (dependent on its type and intensity) and genetic factors. In reinforcement learning (RL) models, agents may occupy different states, and undertake different actions in order to acquire rewards. The values of expected future reward are learned for each state-action pair. How these values are updated and how actions are chosen is controlled by certain meta-parameters ñ learning rate, future reward discount factor. Different values of these parameters may lead to different behavioural strategies for dealing with the environment. Neuromodulators such as dopamine, serotonin, norepinephrine, and acetylcholine are hypothesized to be the neural substrates of such meta-parameters. Stress hormones as well as individual genetic background significantly influence neuromodulation. To learn more about influences of stress and genotype on processes of learning and action choice, we carried out 5-hole-box light conditioning experiments with C57BL/6 and DBA/2 mouse strains. We exposed some of the animals to different kinds of stress to evaluate its effects on immediate performance, and also tested their long-term memory after a break of 26 days. Then, we used a simple discrete state RL model to formalize their behaviour. For each experimental day, we estimated a set of model meta-parameters that produced the best fit between the model and the animalis performance, including a number of different performance measures. We observed characteristic dynamics of estimated meta-parameters over the process of learning, which significantly differed between the 2 strains and among different stress conditions.	<ul> <li>elenaschuh@gmail.com</li> <li>On the way to understanding olfactory perception there is a big gap to overcom between understanding psychophysical odor descriptions (like pineapple) and how these are evoked in the sensory system e.g. due to single chemical properties of the odorant (like hexyl butyrate). In recent work we intensively discussed the psychophysical side of this problem and proposed a mapping framework for estimating similarities of odor quality descriptors. In this work we try to use our knowledge about odor similarity to learn about the context of phylogenetic similarity of Odor Receptor Proteins (ORPs) and its meaning for odor quality. It has been shown that neurons expression regions. Assuming that the evolutional developement of olfactory receptors went along a certain functional specification, it appears to be reasonable that phylogenetic similar</li> <li>receptors might work similar in terms of odor quality coding. The question arises, what might be an appropriate measure for ``similar", i.e. can we find a</li> </ul>	
	Perception Space Analysis: From Color Vision to Olfaction	
Anti-Hebbian learning may underlie both familiarity discrimination and feature extraction	Amir Madany MamloukMonday Poster -M83Martin Haker, Thomas Martinetz	
Andrew Lulham Sunday Poster –S95 Simon Vogt Rafal Bogacz Malcolm W. Brown University of Bristol,Bristol, UK	Institute for Neuro- and Bioinformatics, Luebeck, Germany <u>madany@inb.uni-luebeck.de</u> , jaschnorkoi@web.de On the way to understanding complex perception taks, just based on psychophysical data, we propose a general framework combining several data analysis methods such as multidimensional scaling and self-organizing maps to	
lulham@cs.bris.ac.uk	derive a topologically conserved map of given psychophysical profiles. Such maps are typically much more accessible for human interpretation and crucial	
simon.vogt@gmx.de Psychological experiments have shown that the capacity of thebrain for discriminating visual stimuli as novel or familiar isalmost limitless. Recent neurobiological studies have establishedthat the perirhinal cortex is critically involved in bothfamiliarity discrimination and feature extraction. However,opinion is divided as to whether these two processes are performedby the same neurons. Two models combining the two processes, basedon Hebbian learning, have been shown to have a lower capacity thanthe model specialised in familiarity discrimination based on anti-Hebbian learning. It has been proposed that the reason forthe poor performance of these two combined models is the inability to extract independent features. Additionally,anti-Hebbian learning is more consistent with experimental dataconcerning neuronal responses and synaptic plasticity in theperirhinal cortex. In this paper we show that a well- known modelof visual feature extraction, Infomax, which uses anti-Hebbian learning can also efficiently perform familiarity discrimination. This model has a significantly larger capacity than previously proposed combined models, particularly when correlation exists between inputs, as it does in the perirhinal cortex. We also discuss further questions that need to be addressed to establish if Infomax is a valid candidate for a model of familiarity discrimination in the perirhinal cortex.	for the understanding of the underlying processes. To illustrate the significance of this work, we set up a small psychophysical experiment in which subjects had to describe colors by a given set of words. Such data can be interpreted in two fundamentally different ways: That is the characterization of colors using several verbal descriptions a stimuli-as-points view and conversely, the characterization of the given verbal descriptions by several stimuli a descriptors-as-points view. We will illustrate that only the latter view enables us to see an objective mapping of the perception space. An interpretation of the psychophysical data in the stimuli-as-points view will evidently produce a map of the stimuli, hence capturing their relative dependencies in the sensory space. In the case of color perception we can show that our framework reproduces the hue circle the origin of the color stimuli from the psychophysical data very aptly. In order to derive a map of the perception space one is tempted to place the descriptors manually into the map of stimuli. We argue that such an approach can only yield a subjective interpretation of the results, since the placement of the descriptors is either based on a-priori knowledge or it would lack solid confidence. To elude this problem we propose the interpretation of the data in an descriptors-as-points view. An embedding directly produces a map of the perception qualities. Finally, on the way to understanding principal features of olfactory perception, we point out that most efforts, focusing on the organization of receptors or neural responses, have constructed maps based on general properties of chemicals. We will use the second approach to finally derive an objective mapping of the odor perception space. We will present our data analysis framework and the application of this framework to both, color and	

data analysis framework and the application of this framework to both, color and olfactory perception.

#### Dynamics of networks of electrically coupled neurons

Reinoud Maex *Tuesday Poster –T38* Laboratory for Theoretical Neurobiology, Institute Born-Bunge, Universiteit Antwerpen, Antwerpen, Belgium, reinoud@tnb.ua.ac.be

There is a renewed interest in the role electrical synapses play in the normal mammalian brain and in functional disorders like epilepsy. Interneurons involved in the generation of fast oscillations were shown to be coupled not only through fast GABAergic synapses but also through dendro-dendritic gap junctions. Axo-axonal gap junctions between pyramidal neurons have been postulated to generate 'ripples' and to initiate seizures (Traub et al. Epilepsia 2001). We examined, by simulating networks of multicompartmental neurons, the relationship between the strength and location of gap junctions and the frequency of the emerging oscillations. Dendro-dendritic or weak, proximal axoaxonal coupling synchronized the network to produce powerful oscillations in the gamma range (30-100 Hz), with optimal frequency inversely related to the electrotonic distance to the soma. Adding electrical synapses in very heterogeneous inhibitory networks induced oscillations even at connections strengths insufficient for synchronization, the mechanism being a reduction of network heterogeneity. Strong axo-axonal coupling elicited a unique, all-ornothing, re-entry phenomenon. This state arose when spikes, passing through the gap junctions and antidromically invading the somata, were reflected, to pass through the junctions again. However, due to impedance mismatch, most antidromic spikes produced only spikelets in the somata. Consequently the axons fired at much higher rates than the somata, generating a mass oscillation of about 200 Hz. This state could persist when all excitatory drive to the network was switched off. Hence in this re-entry state, the axons fired autonomously at 200 Hz, whereas the somata, functionally decoupled from the axons, produced spikes at a much lower rate, determined by their own level of excitation. Contrary to intuition, this re-entry phenomenon was most likely to occur with gap junctions located far from the somata and during low levels of network excitation, suggesting that the afterhyperpolarisation following each somatic spike protects axons from entering into their autonomous state. The high junctional conductance needed to evoke this re-entry state is certainly nonphysiological, as it would prevent most somatic spikes from reaching the terminal axon. However, regular trains of spikelets at 180 Hz have been recorded from Purkunje cells in cerebellar slices in Ca2+-free medium (blocking all transmitter release but presumably also enhancing junctional conductances), lending further support to the existence of axo-axonal gap junctions in the mature mammalian brain (S.J. Middleton & M.A. Whittington, personal communication).

# Modeling signal transduction using Itô stochastic differential equations and the Gillespie algorithm

Tiina Manninen Monday Poster –M39 Marja-Leena Linne, Keijo Ruohonen Tampere University of Technology, Tampere, Finland. <u>tiina.manninen@tut.fi</u>, marja-leena.linne@tut.fi

The modeling and simulation of complex reactions, pathways, and networks have recently grown interest. In addition to deterministic approaches, for example the law of mass action and the Michaelis-Menten kinetics, several discrete and continuous stochastic approaches have been developed to simulate the time-series behavior of biochemical systems Stochastic approaches are needed because small numbers of molecules may be involved in collisions, making reactions random. One of the well-known stochastic approaches is the Gillespie stochastic simulation algorithm (SSA), with which individual chemical reactions are simulated stochastically. However, simulations of discrete stochastic approaches can be relatively time-consuming, and the continuous regime may be favored over discrete approaches for computational reasons. It is therefore necessary to study alternative ways to incorporate stochasticity and to seek approaches that reduce the computational time needed for simulations, yet preserve the characteristic behavior of the system in question. In our previous work, we have developed ItÙ stochastic differential equation (SDE) models for neuronal signal transduction networks. In this work, we use two different types of test cases: a less complex signal transduction pathway and a larger network to make a comparative analysis of different kinds of stochastic approaches, that is the ItU SDEs and the SSA. Different kinds of stochastic approaches are found to produce similar results, although the fine details of the responses vary slightly, depending on the approach and the test case. Based on our studies, it is beneficial to combine a microscopic and macroscopic regimes in simulations, in which small numbers of molecules are computed using the microscopic approach and for larger numbers of molecules the fast stochastic macroscopic approach is used. Several hybrid methods have previously been developed. However, further refinements of the algorithms need to be done before hybrid methods are routinely used in modeling the biochemical reactions among bioscientists. The ItÙ SDEs developed by us may serve as a conceptual bridge between the chemical master equation and the traditional deterministic reaction rate equation, and provide a new, computationally faster stochastic modeling tool for studying the emergent phenomena in complex neuronal signaling networks.

#### A model of a mechanoreceptor and sensory circuit in the fruit fly

Petr Marsalek Martin Zapotocky Sunday Poster – S68

Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

marsalek@cesnet.cz martinz@mpipks-dresden.mpg.de

The aim of this work is to understand how fruit fly uses sensory input from wings and other structures to be able to quickly maneuver during flight. We model mechanoreceptors on the fly wing and on the halteres (club shaped extremities, which are the modified second pair of wings and function as sensory flight stabilizers). We study the function of the mechanoreceptors within the flight control neural circuit. The mechanoreceptor neuron is modeled by two sets of ordinary differential equations. The first set consists of the spring model gating the mechanically sensitive ion channel. The second set is the leaky integrate-and-fire neuronal model. Output of the first set (displacement) is used through the function of channel opening probability as input (ionic current) to the second equation set. The spring and the leaky integrator equations are linear, however they contain other nonlinear elements: threshold for spike generation, adaptation current and mechanoreceptor currents. The set of the equations is solved numerically. By a simple change of the value of the adaptation time constant we reproduce two versions of the mechanoreceptor neuron spike trains. One train corresponds to the wild type response and the other to the NOMPC mutant response [Walker et al, Science, 2000]. Some of the monosynaptic flight equilibrium reflexes originate at the sensory neurons. The centripetal part of the reflex leads to the thoracic ganglion, where it makes a synapse onto motoneurons driving muscles for wing flapping. The flapping in turn mechanically stimulates wing mechanoreceptors, closing this way a mechanosensory feedback loop used in flight control. We model some properties of this loop. This report deals with a theoretical part of an ongoing joint project with two other experimental laboratories. We hope that we will also be able to comment on some of their new experimental results.

### Sensory coding and burst firing: a behavioral link.

Gary Marsat Gerald S Pollack Monday Poster -M69

McGill University, Montreal, Canada

gary.marsat@mail.mcgill.ca gerald.pollack@mcgill.ca

Behaviorally relevant sensory information must be extracted by nervous systems in order to participate to the animalis response. Sensory neurons encode changes in the environment in the structure of their spike trains. Specific stimulus features are sometime encoded by short bursts of action potentials. Isolated spikes in these neurons often carry different or less information about the stimulus. Despite evidences showings that bursting neurons can perform feature extraction tasks, demonstrations of the behavioral relevance of this encoding strategy are lacking. Here we show that AN2, an auditory interneuron of crickets, encodes salient features of the stimulus by burst of action potential and that isolated spike produced by this neuron are less reliable at indicating the occurrence of specific features of the stimulus. Bursts are also better at representing stimulus location. Finally, we show that bursts encode stimulus features that have a particular behavioral importance. Our results indicate that AN2 extract behaviorally important features of the stimulus to which the cricket reacts and that AN2 signals these features with bursts.
#### Modeling memory transfer in cerebellar vestibulo-ocular-reflex learning

Naoki Masuda, Shun-ichi Amari	Tuesday Poster – T60
CNS, Wako Saitama, Japan	
masuda@brain.riken.jp, amari@brain.riken.jp	

It has been argued for a long time whether the motor memory is stored in the cerebellar cortex (flocculus hypothesis) or in the cerebellar nuclei (brainstem hypothesis). A couple of experimental and numerical stuies suggest that both sites may be responsible for motor learning and its consolidation. Long-term memory is often supposed to be located at the synapses connecting the mossy fibers and the cerebellar nuclei, and LTP induced by the two afferents to the cerebellar nuclei, one coming from the mossy fibers and the other from the Purkinje cells is compatible with memory transfer. With other rules such as the Hebbian and supervised learning rules, transfer is impaired. We investigate the issue of computational power of these memory sites using a dynamical-system modeling of gain and phase learning in the vestibulo-ocular reflex (VOR). Marr, motivated by a huge mass of granule cells in the flocculus pathway, first conjectured that the cerebellar cortex operates as a perceptron.nn By contrast, the neurons and synapses in the cerebellar nuclei are not so large in number, and it may be the case that a part of the acquired information cannot be transferred to the brainstem. Since animals must learn the correct repsonse timing in addition to the VOR gain, we represent the vestibular signal by sinusoidal time series. The desired response corresponding to the motor output is also represented by a sinusoidal, but with a desired gain and phase (response timing) different from the input ones. We show that the response gain is transferred to the vestibular nuclei, whereas the response timing is not necessarily. Furthermore, only the Pukinje-cell dependent learning rule, not the Hebbian or Supservised rules, is capable of transferring both gain and phase information from the flocculus to the cerebellar nuclei. Naturally though, phase transfer is impossible when we limit the computational capability of the brainstem memory site. Our model also replicates so-called savings phenomena in which higher performance is achieved in later days of training.

### Suppressive effects in visual search: A neurocomputational analysis of preview search.

#### Eirini Mavritsaki

Sunday Poster –S7

Dietmar Heinke, Glyn Humphreys, Gustavo Deco School of Psychology, University of Birmingham, Birmingham, UK <u>e.mavritsaki@bham.ac.uk</u>, d.g.heinke@bham.ac.uk

The visual world contains a vast amount of information, only some of which is relevant to our behavior; Hence, we need a selection mechanism that separates relevant from irrelevant information. It is well-known that humans utilize iselection by spaceî to process only information at certain locations. However, only recently have there been detailed studies of selection using temporal cues between visual stimuli. To study the iselection by timeî Watson and Humphreys (1997) devised a new version of visual search. In the preview search procedure, distractors are split to appear at two different points in time. Typically, participants are able to ignore items that appear at the first point in time (old items) and search only the new items. Watson and Humphreys (1997) termed this visual marking effect. There are only a few biologically inspired models of visual search but presently no neurocomputational model of visual marking effect. Here, we used the architecture for the system proposed by Deco and Zihl (2001) with a biological plausible neuron model developed by Deco and Rolls (2005), and assessed whether the frequency adaptation mechanism could generate the visual marking effect in this architecture. Simulations showed that frequency adaptation was necessary but not sufficient to simulate visual marking, whereas marking could be simulated by adding an active inhibitory process. Here, inhibition was applied to the features of old items during the preview period. This active inhibitory process arose from signals originally outside the search module, matching fMRI data implicating a role for the superior parietal lobe in marking effect (Pollman et al., 2003).

### Map models of the visual cortex: The metric of the stimulus space affects the map formation

N. Michael Mayer, Minoru Asada Monday Poster – M48 Handai FRC, Osaka University, Suita, Osaka, Japan norbert@er.ams.eng.osaka-u.ac.jp, asada@er.ams.eng.osaka-u.ac.jp

The starting idea is to find a link between high-dimensional and feature models of the visual cortex V1. We derive a Riemannian metric for feature approaches that reflects properties of a generic high-dimensional approach of V1, that models a self-organizing formation process. We demonstrate how a metric can be constructed that obeys certain symmetry constraints and at the same time shows a coupling between the orientation preference and the change of the position of the receptive field in the visual space. In a second step we apply this metric to an elastic net approach and a modified Swift Hohenberg equation. The numerical simulations show that depending on the strength of the coupling term different types of pattern appear after a sufficiently long learning process, indicating that in the case of a strong coupling strength a local interaction is sufficient for producing patterns with a non-vanishing density of pinwheels.

### Burst dynamics in the spontaneous activity of an invertebrate neuronal network

Alberto Mazzoni Tuesday Poster –T51 Elzabeth Garcia-Perez, Frederic Broccard, Paolo Bonifazi, Vincent Torre SISSA, Trieste, Italia, <u>mazzoni@sissa.it</u>, garcia@sissa.it

Spontaneous bursting activity of diverse neuronal networks is showing some characteristics features of critical systems, like scale invariance. This behavior can be explained within the paradigm of self organized criticality, shedding light on interactions role in shaping the network activity. In order to see how bursts are originated we studied the activity of the leech ganglion ñ the functional unit of the leech nervous system - in a multiscale analysis ranging from single identified neurons, to cluster of neurons of various size, up to the the whole ganglion. Interspike interval distribution for single neurons can be classified according to three different dynamics: periodic, exponential distribution of waiting times and bi-exponential distribution. The latter indicates the presence of bursting activity: we found that size and duration of bursts have a power law probability distribution. When a sufficiently large network of neurons is considered multiplicative interactions among neurons make increase synchronously their firing rate and propagate the burst. We were able to increase or decrease burst occurrence frequency with pharmacological modulations of interaction strength. To test scale invariance properties of the network activity we considered first burst in the complete network then we analyzed separately the activity of the roots emerging from the two sides of the ganglion. Each semiganglion displayed critical behavior and power laws describing both life and size distribution of the bursts are similar to those describing bursts over the whole network.

#### An Embodied Cerebellar Model for Predictive Motor Control Using Delayed Eligibility Traces

Jeffrey McKinstry Gerald Edelman, Jeffrey Krichmar The Neurosciences Institute, Point Loma N

The Neurosciences Institute, Point Loma Nazarene University, San Diego, jeffmckinstry@ptloma.edu, edelman@nsi.edu

Tuesday AM Oral

The cerebellum is known to be critical for accurate adaptive control and motor learning. We propose here a novel mechanism by which the cerebellum may replace reflex control with predictive control. This mechanism is a learning rule (the delayed eligibility trace rule) in which synapses onto a Purkinje cell or onto a cell in the deep cerebellar nuclei become eligible for plasticity only after a fixed delay from the onset of suprathreshold presynaptic activity. To investigate the proposal that the cerebellum is a general-purpose predictive controller guided by a delayed eligibility trace rule, a computer model based on the anatomy and dynamics of the cerebellum was constructed. It contained components simulating cerebellar cortex and deep cerebellar nuclei, and it received input from a cortical area MT and the inferior olive. The model was incorporated in a real-world brain-based device (BBD) built on a Segway robotic platform that learned to traverse curved paths. The BBD learned which visual motion cues predicted impending collisions and used this experience to avoid path boundaries. During learning, it adapted its velocity and turning rate to successfully traverse various curved paths. By examining neuronal activity and synaptic changes during this behavior, we found that the cerebellar circuit selectively responded to motion cues in specific receptive fields of simulated area MT. The system described here prompts several hypotheses about the relationship between perception and motor control and may be useful in the development of general-purpose motor learning systems for machines.

Learning to perform cognitive tasks by as future reward	sociating sequences with expected	The modulation of spike rate in t by a virtually moving	the dorsal nucleus of the lateral lemniscus
Jeffrey McKinstry Justin Kerk	Sunday Poster –S86	Hamish Meffin Benedikt Grothe	Monday Poster –M72
The Neurosciences Institute, Point Loma Na San Diego, California, USA, jeffmckinstry@ptloma.edu	zarene University	Division of Neurobiology, Department Biology Ludwig-Maximilians-University, Martinsried, Germany	
jkerk@ptloma.edu	wish store and reasoning sources	meffin@zi.biologie.uni-muenchen. grothe@zi.biologie.uni-muenchen.	
Neurophysiologists have reported neurons w of motor actions, sensory events, or both. Al indicate that the basal ganglia contain signal reinforcement learning, a theoretical mechar value of future reward. In fact, Samejima et 2005) report neural responses in the striatum reinforcement learning, Q-learning. We invo- these two known brain mechanisms. We car learn any task modeled by a finite memory r finite state machines. We demonstrate throu, model can learn two interesting cognitive ta- processes and decision making when learned a class of models known as FMMs which ca Then a new model will be introduced, in the tasks that can be modeled by FMMs by 1) r actions and percepts obtained via interaction these sequences, learn an action-value assoc learning. Finally we show through computer to perform two cognitive tasks used by neur- of intelligent behavior in primates: delayed a repeated reversal. This algorithm demonstra actions in temporal context is sufficient to le tasks. In addition, the learning curve on the 1 mammals, suggesting along with physiologi learn complex tasks in this manner.	so, mounting evidence seems to s predicted by the theory of hism for optimizing the expected al (Science 310(5752):1337-40, a consistent with a specific form of estigate the utility of combining a show that this combination can nachine (FMM), a useful subset of gh computer simulation that this sks thought to reflect executive d by animals. First, we will describe n be used to model complex tasks. form of an algorithm, that can learn nemorizing short sequences of with the FMM, and 2) for each of iated with each action using Q- simulation that the model can learn oscientists to explore the acquisition alternation and go/no-go with tes that remembering the utility of arn certain complex behavioral reversal task is similar to that of	brainstem. Neurons in the DNLL th carry information about sound posis sensitivity to interaural intensity dif a powerful GABAergic inhibition the end of the stimulus. This may cause modulated by the velocity of a move investigated by making in vivo extr DNLL of Mongolian gerbils during and with dynamic IIDs mimicking fitted to the static IID data, with a gethe dynamic stimuli. Preliminary re- contra- to ipsi-lateral directed move rate for angular speeds of 2.5 Hz cor result is in rough agreement with the stimuli that mimic ipsi- to contra-la of spike rate with angular speed in <b>Learning the structure of correlat competitive STDP</b> Hamish Meffin Anthony Burkitt	mniscus (DNLL) is situated in the auditory hat respond best to high frequency sounds tion in the horizontal plane by virtue of their fferences (IIDs). These neurons also receive hat can persist for up to 60ms following the e the spike rate of these neuron to be ving sound source. This hypothesis was racellular recording from neurons in the g the presentation of stimuli with static IIDs a moving sound source. A simple model was good match, and used to predict responses to esults indicate that for stimuli that mimic ement there is a pronounced increase in firing ompared to 0.5 Hz compared to 0.1 Hz. This he predictions of the model. In contrast, ateral directed movement show no modulation contradiction to the predictions of the model. <b>Ited synaptic subgroups using stable and</b> <i>Tuesday Poster –T81</i>
	e ,	Julien Besson David Grayden	
Testing the SOCRATIC model of the hipp and recall	oocampus for sequence storage	Division of Neurobiology, Departn Ludwig-Maximilians-University, M	
Jeffrey McKinstry Tyler Netherland	Tuesday Poster – T7	meffin@zi.biologie.uni-muenchen. aburkitt@bionicear.org	
The Neurosciences Institute, Point Loma Na California, USA jeffmckinstry@ptloma.edu, tnetherl@ptloma		Synaptic plasticity must be both co the structure of neural inputs is to c	mpetitive and stable if ongoing learning of occur. Most previous models of STDP exhibit but not both. G\"utig have introduced a
The goal of this study was to test, using commodel of the hippocampus proposed to explire recalled in this structure (J.E. Lisman and N Hippocampus, 11(5):551-68.). In the model, autoassociative network and the CA3 region Our simulations show that the model is capa learning and recalling memory sequences, an SOCRATIC model for the first time: 1) if th autoassociative and heteroassociative networ capable of accurate storage and recall of terr with the function of the DG in such a model SOCRATIC model of hippocampal function Dentate Gyrus and CA3 which allows the le sequences. Evidence shows that the DG netv input from the entorhinal cortex via the perfi- recurrent network via mossy cells, and that the excitatory feedback to the DG network. Lisr DG behaves as an autoassociative network via heteroassociative network, and these networ The network is proposed to function as follo are consecutive patterns in a sequence to be SOCRATIC model CA3 associates pattern 4 associates pattern A and B with themselves. produce B′, a possibly corrupted ver the corrupted input pattern Bí and produces prediction is that interference with the functi- network performance. This paper tests these	ain how sequences are stored and A. Otmakhova (2001). the Dentate Gyrus (DG) is an is an heteroassociative network. ble of performing the task of nd confirm two predictions about the e DG and CA3 function as rks, respectively, then they would be poral sequences, and 2) interfering degrades performance. The establishes a loop between the arning and correct recall of pattern work and CA3 network both receive orant path, that the DG region is a he CA3 network generates nan makes two predictions. First, the while the CA3 behaves as an ks interact via reentrant connections. ws. Suppose that patterns A and B stored in the hippocampus. In the A with pattern B, and the DG Given pattern A, the CA3 will rsion of pattern B. The DG corrects the correct pattern, B. The second ion of the DG will diminish the	\cite {Gutig03}). Experimental evid dependence \cite {Bi98}. In this stu that have both these desirable proper subgroups of synapses that are corr occurrence of simultaneous input sy formation is studied, illustrating wi the learning rate is small, multiple a given the same inputs, with the out configuration. For large learning ra resulting in neurons without consis between, a unique and stable synap synaptic structure exhibits a bimod selectively to one or more of the su	ht dependence that overcome this problem lence supports some form of weight dy a wide class of STDP models is identified erties in the case where the input consists of related within the subgroup through the pikes. The process of synaptic structure ith one particular class of these models. When alternative synaptic structures are possible come depending on the initial weight tes the synaptic structure does not stabilize, tent response properties. For learning rates in stic structure typically forms. When this al distribution, the neuron will respond ibgroups. The fraction of potentiated by the balance between potentiation and

#### Dendritic GABAb currents can induce a shift to a burst firing mode in ELL

William Mehaffey Monday Poster –M12 Fernando Fernandez, Leonard Maler, Raymond Turner Hotchkiss Brain Institute, University of Calgary, Calgary, AB, Canada whmehaff@ucalgary.ca, ffernand@ucalgary.ca

Pyramidal cells in the electrosensory lateral line lobe (ELL) of the electric fish Apteronotus leptorhynchus display a characteristic mode of burst discharge that has been shown to have important implications for sensory coding. This mode of burst discharge involves a coupling of active dendritic and somatic compartments by a depolarizing afterpotential (DAP) caused by the generation of a dendritic spike. Recent work has involved characterization of synaptic mechanisms for modulation of the burst dynamics. A diffuse inhibitory feedback projection creates GABAergic contacts with pyramidal cells on their proximal dendrites, activating GABAb receptors. Pharmacological activation of GABAb receptors in ELL pyramidal cells by focal application of baclofen in vitro leads to a shift in both firing and burst threshold. However, activation of these conductances has a greater effect on tonic firing threshold than on burst threshold, causing a decrease in tonic firing, and a relative increase in burst firing. A reduced model of burst dynamics in our cells was able to replicate these effects, and suggests that the shift to burst firing mode requires a dendritic locus of inhibition. A two parameter bifurcation analysis of our reduced model shows the shift to burst firing requires GABAb type synaptic conductances (Erev=-90), but fails to function with GABAa type conductances (Erev=-70). This is consistent with previous results showing no switch to bursting mode after dendritic activation of GABAa receptors by muscimol. We suggest that this shift to burst firing mode after activation of dendritic inhibitory conductances is due to a change in the relative coupling between somatic and dendritic voltages. The increased delay increases the effectiveness of the DAP on the somatic membrane voltage, leading to an immediate burst discharge. In ELL pyramidal cells, dendritic inhibition has non-linear effects due to the inherent dynamics of the cell, which may be able to drastically influence the coding properties of the cell.

### Comparison of Dynamical States of Random Networks with Human EEG

Ralph Meier Monday Poster – M100 Arvind Kumar, Andreas Schulze-Bonhage, Ad Aertsen Inst. Biol. III, A. L. University Freiburg, Freiburg, Germany meier@biologie.uni-freiburg.de, kumar@biologie.uni-freiburg.de

Certain activity states of random neural network models have been found to resemble ongoing cortical activity in vivo in terms of spike statistics. While there are promising approaches, there is currently no standard procedure to relate network model dynamics to experimental population activity measures such as LFP, ECoG or EEG. Here, we try to bridge the gap between network activity states and relevant states in electrophysiological signals (EEG) recorded from humans. We simulated randomly connected networks of 50,000 leakyintegrate-and-fire type neurons (80% excitatory, 20% inhibitory neurons), representing a 0.5mm2 slice of cortex using the NEST simulation environment. In the first network type (referred to as homogeneous) all neurons had identical passive properties, in the second (referred to as heterogeneous) the passive parameters were chosen from a normal distribution. We obtained a network population (Npop) activity signal by binning the spikes of all neurons. The spectral bandwidth of Npop was much wider than the EEG bandwidth. To draw a comparison between Npop and EEG, we first transformed Npop, using an alpha-function shaped kernel, to a signal (Sim-EEG) closely resembling the human EEG. We compared the resulting power spectral density (PSD) characteristics to those of the human EEG from awake, behaving subjects. We found that Sim-EEG for asynchronous irregular (AI) and synchronous irregular (SI) network states showed a good match with the human EEG - especially in the theta and delta bands. The Sim-EEG for the heterogeneous network model resembled the human EEG better, even in alpha and beta frequency bands. The small mismatch between Sim-EEG and human EEG could be due to an inappropriate choice of the convolution kernel. Therefore, we empirically estimated the kernel by assuming a linear mapping between Npop and human EEG. We found that convolving Npop with either the empirically estimated kernel or a gamma-function approximation gave a better fit, as measured by correlation of PSD-bands with the human EEG. In summary, we found that AItype network activity is closely related to the human EEG in the awake state. Currently, we are studying the relation between other dynamic network states and clinically or behaviorally relevent EEG states. While there is good hope for bridging the gap between network simulations and human population activity recordings, further improvements in both, network models and conversion procedures may be needed.

#### Improvement of spike coincidence detection with facilitating synapses

Jorge Mejias Joaquin Torres Sunday Poster - S89

Dep. of Electromagnetism and Material Physics Granada, Spain

jmejias@onsager.ugr.es jtorres@onsager.ugr.es

A realistic model of activity-dependent dynamical synapses and a standard integrate and fire neuron model are used to study the conditions in which a postsynaptic neuron is able to detect incoming signals from N different afferents. It is known that synaptic depression and facilitation are important short-term mechanisms which play a crucial role in the transmission and coding of information through synapses. In this work we extend other previous studies that consider only depressing synapses to the more general case in which facilitation is also included. Our results show that facilitation enhances the detection of correlated signals arriving from a subset of presynaptic excitatory neurons. Thus, the analysis of the system shows that is possible to find regions of good coincidence detection, even in situations in which synaptic depression does not perform well. In addition, facilitation reveals the existence of a frequency value which allows the best performance in the detection of signals for a wide (maximum) range of the values of the neuron firing threshold. This optimal frequency can be controlled by means of facilitation control parameters.

#### Spike Patterns in Heterogeneous Neural Networks

Raoul-Martin Memmesheimer Marc Timme Sunday Poster – S98

Max Planck Institute for Dynamics, Bernstein Center for Comp. Neuroscience Goettingen, Germany

rmm@chaos.gwdg.de timme@chaos.gwdg.de

Repeated, precisely timed patterns of spikes have been experimentally observed in different neuronal systems [1]. They are discussed to be key elements of neural computation [2]. It is, however, still an open question how these patterns emerge in the dynamics of neural networks [3]. Here we demonstrate that deterministic neural networks with delayed interactions, complex topology and strong heterogeneities can yet display precisely timed periodic patterns of spikes. We develop an analytical method to design networks exhibiting a predefined pattern. This pattern may have realistic temporal extent as well as complicated temporal structure. Also, the same pattern can exist in very different networks. Its stability depends on the particular coupling architecture, as can be shown by linear stability analysis. Finally, using a nonlinear stability analysis, we establish that networks with purely inhibitory (or purely excitatory) coupling can either store only stable or only unstable non-degenerate patterns. [1] M. Abeles et al., J. Neurophysiol. 70:1629 (1993); Y. Ikegaja et al., Science 304:559 (2004); K. Gansel and W. Singer, Society for Neuroscience Abstracts 276.8 (2005). [2] M. Abeles, Science 304:523 (2004). [3] I.J. Matus Bloch and C. Romero Z., Phys. Rev. E 66:036127 (2002); D.Z. Jin. Phys. Rev. Lett. 89:208102 (2002); M. Denker et al., Phys. Rev. Lett. 92:074103 (2004).

#### Modelling adaptation aftereffects in associative memory

Federica Menghini,	Sunday Poster – S87
Nicola van Rijsbergen, Alessandro Treves	
SISSA, Trieste, Italy, menghini@sissa.it, nicolavr@sissa	a.it

We implement a very simple autoassociative network with a two layer structure. The first layer is an input station and projects the signal (through not modiafiable feed forward connections) to the second layer where activity circulates in the recurrent collateral (RC) connections. Such a network can be thought as a very simplified model of a single layer cortex with the first layer corresponding to the thalamic input. We investigate the contribution of activity in the RC during learning, and compare the model to data form our psychophysical experiment replicating the category aftereffect when the stimuli are faces with ambiguous emotional expressions. Two learning conditions are explored: RC active and RC not active during learning, where learning and testing are separate phases. During the training phase randomly generated patterns are presented singly, and activity circulates for 10 time steps and weights are then updated with a modified Hebbian rule. The testing phase is realized presenting a noisy version of a single pattern, observing the trajectory of activity in the network, and predicting the pattern from which the cue was derived, measuring the performance as percent correct. We find that percent correct increases with training epochs when RC are not active during learning, and the network preserves the ability of distinguishing among them. When RC are active during learning, instead, the performance increases quickly in the first two training epochs, but then it drops dramatically. We show that the result is related to the collapse of some of the patterns into the same basin of attraction. To reproduce the adaptation aftereffect we describe in the psychophysical experiments, we study the behaviour of the network when we introduce a "prime" pattern, before the retrieval cue. We find that to reproduce the experimental results, we need to introduce an adaptation factor in the firing rates that takes into account neurons fatigue, which we model as difference of two exponentials.

### A leak potassium current and its functional impact on thalamic relay cell function

Patrick Meuth Monday Poster –M18 Sven Meuth, Hans-Christian Pape, Thomas Budde Westfalische Wilhelms-Universitat Munster, Munster, Germany patrick.meuth@gmx.de,sven.meuth@gmx.de

Depending on the functional state of the central nervous system (CNS), thalamic relay neurons display two distinct activity modes. During periods of wakefulness tonic activity ensures the faithful transfer of incoming sensory information to the cerebral cortex, while during sleep burst discharges result in a reduced sensory responsiveness of the brain. Although for thalamocortical relay neurons the resting membrane potential determines the maintenance and switch between their functional activity modes, rather little is known about the underlying ionic conductances. In general, the resting membrane potential is assumed to be determined by channels active below firing threshold, with K+ leak channels playing a major role. To shed some more light on this issue, we used a combined electrophysiological and single-compartment modelling approach. A previously described model based on the mathematical descriptions of the currents IA, IC, IL, IT, INa-persistent and Ih (carried by HCN-channels, hyperpolarization-activated cyclic nucleotide-gated channels) was adapted and extended by the Hodgkin-Huxley formalisms of the inward rectifying current IKIR and the leak potassium current ITASK (carried by TASK channels, TWIKrelated acid-sensitive K+ channels). The model revealed a contribution of INapersistent (~ 2-5%), Ih (~ 5-10%), ITASK (~ 49%) and other potassium conductances to the standing-outward current (ISO) of thalamocortical relay neurons, thereby confirming results obtained by the use of ion channel blockers (TTX, ZD7288, pH 6.4, Ba2+, TEA/4-AP) in whole-cell patch-clamp experiments. In a next experimental step we focused on the interaction of ITASK and Ih and their functional impact on the resting membrane potential and firing pattern of these cells. Pharmacological (ZD7288) or genetic knock out (HCN2 deficient mice) of HCN channels was simulated by setting Ih to 0%. while extracellular acidification was mimicked by the reduction of ITASK to 10% and Ih to 75%. From a holding potential of -72mV the initial model cell responded to depolarizing stimuli with burst firing. When the effects of HCN channel knock out or extracellular acidification was simulated separately behaviour remained unchanged. By combining these two effects (Ih to 0% and ITASK to 10%), the model showed a depolarization to -58mV accompanied by tonic firing. These findings are in good agreement with data revealed from relay neurons of the dorsal geniculate nucleus (dLGN) and demonstrate a counterbalancing influence of HCN and TASK channels on the membrane potential of thalamocortical relay neurons.

#### A comprehensive kinetic model of the exocytotic process

Monday Poster -M31

Aviv Mezer Uri Ashery, Esther Nachliel, Menachem Gutman

Tel Aviv University, Tel Aviv, Israel aviv@hemi.tau.ac.il, uria@post.tau.ac.il

The exocytosis a well coordinated process, where intracellular trafficking vesicles fuse with the plasma membrane. In neurons and in neuroendocrine cells the exocytosis is a multi-step process that is regulated by calcium and can be described as a sequential process of vesicle maturation between defined states which are termed as 'pools'. At the molecular level, exocytosis is mediated by a sequence of interactions between cytosolic, vesicular and plasma membrane proteins. The process can be measured with chromaffin cells and in a few large synaptic terminals at a millisecond accuracy using membrane capacitance measurements. These studies have revealed several kinetic components in the process of exocytosis and elucidated the involvement of several synaptic proteins and the sequence of the reactions between them, even though some steps are still not well defined. Recently, we presented a kinetic model, based on a strict chemistry kinetics formalism, that accurately reconstructs the exocytosis as measured under various experimental protocols, where the chromaffin cells were challenging by various stimuli before exocytosis was induced. The model linked the known interactions between the SNARE proteins into an array of chemical equilibria that were converted into a set of differential rate equations. The integration of these equations, with the proper values assigned to the rate constants of each partial reaction, generated the dynamics of the system. This refinement of the model expands its scope rendering it with predictive power. We suggest that the present system can be used as a standard representation of the exocytotic process which may evolve into a diagnostic tool revealing the sites where the sequence of events is fundamentally impaired.

#### Visuomotor Mappings and Sequence Learning

Krishna Miyapuram Raju Bapi Kenji Doya Sunday Poster – S85

University of Cambridge, Cambridge, England

kpm23@cam.ac.uk bapics@uohyd.ernet.in

In day-to-day life, we associate different kinds of visual information into appropriate motor commands. Using a modified 2x6 sequence task, we set out to investigate sequence learning under different visuomotor mappings. Subjects learned a sequence of finger movements by successively completing six sets of two keys each by trial and error. The sequence to be learnt was determined by either the spatial position or colour of the cues. Further, the response to be executed was determined by the spatial position (transformational mapping) or by the colour (arbitrary mapping) of the visual stimuli. A baseline task involving keypresses in response to randomly generated visual stimuli presented one at a time, using the same visuomotor mapping as in the sequence conditions was used. Slower response times were observed for arbitrary mapping as compared to spatial mapping in the baseline tasks. On the other hand in the sequence conditions, response times were faster when the finger movements were fixed as compared to when they were variable across trials. This effect was observed irrespective of the type of visuomotor mapping used to perform the sequence. These results suggest that sequence learning can benefit from an effector dependent representation fo efficient performance.

#### Entorhinal Input and Global Remapping of Hippocampal Place Fields

Joe Monaco	Tuesday Poster –T3	Marcelo Montemurro	Sunday Pos
I.A. Muzzio, L. Levita, Larry Abbott		Riccardo Senatore, Stefano Panzeri	

Center for Theoretical Neuroscience, Columbia University, New York, USA joe@neurotheory.columbia.edu, im128@columbia.edu

Recent experimental data have begun to elucidate the spatial coding features of entorhinal cortex (EC) neurons in the rat (e.g., Fyhn et al, 2004). Their computational role in the EC-CA3 hippocampal pathway is not known. It is known that CA3 neurons have place fields that are stable for familiar environments, but are randomly recoded upon entering novel environments. Here, we show that EC spatial coding may contribute to this remapping mechanism. Encoded place fields may be stabilized by Hebbian learning at the perforant path synapses, but the remapping occurs too quickly for it to be dependent on synaptic modification. Layer II of dorsomedial EC contains "grid" cells with spatially periodic, tessellating place fields (Hafting et al, 2005). We hypothesized that small noisy perturbations of the spatial phase between overlapping grid cells may yield large discrete place field changes in a competitive winner-take-all network. Competition occurs between activity peaks that are larger than some threshold: this allows for the possibility that no place field will form. Thus, in a novel environment where there is no pre-existing spatial map to be retrieved, structural heterogeneities in grid cell place fields may lead to a novel map which is instantly available to the animal. We show that this remapping occurs robustly in both 1- and 2-dimensional models of varying complexity. Further, we explore the addition of a CA3-like postsynaptic unit driven by this EC activity. Hebbian learning at these EC-CA3 synapses is sufficient to stabilize newly formed spatial maps such that they may be retrieved during subsequent exposure. However, from tetrode recordings in mouse CA1, we know that place field stability can be attentionally modulated (Kentros et al, 2004). Here, such modulation may be a shift in the competitive threshold for field formation or an explicit change in the spatial metrics of the grid cells. Both possibilities are compared to CA1 rate maps in conditions requiring selective attention to either visuospatial or olfactory cues (Muzzio et al, 2005). Finally, we suggest that this simple EC-CA3 interaction is a candidate mechanism for the remapping of novel environments. --- Fyhn M, et al. (2004). Science. 305: 1258-1264; Hafting T, et al. (2005). Nature. 436(11): 801-806; Kentros CG, et al. (2004). Neuron. 42: 283-295; Muzzio IA, et al. (2005). Soc for Neurosci Abstracts, Washington, D.C.

### How do stimulus-dependent correlations between V1 neurons affect neural coding?

Fernando Montani Adam Kohn, Simon Schultz Sunday Poster – S20

Imperial College London, Bioeng. Dept, London, UK <u>f.montani@imperial.ac.uk</u>, adamk@cns.nyu.edu

Spikes fired by nearby neurons are often correlated, but the significance of this correlation for perception is unclear. To evaluate the effect of correlation on the population coding of sensory information, we recorded responses of pairs of single neurons in primary visual cortex (V1) of the anaesthetised macaque monkey to stimuli of varying orientation and contrast. Both trial-to-trial variability and synchrony were found to depend on both stimulus orientation and contrast (A. Kohn et al, J Neurosci 25:3661-73, 2005). We used information theory to examine whether this stimulus-dependent correlation could contribute to the neural coding of orientation and contrast by pairs of V1 cells. We computed mutual information using the Nemenman-Shafee-Bialek estimator (Phys. Rev. E 69, 056111-6), and compared the ensemble information available from the pair of cells with the sum of the single cell information values. This allowed us to assess the degree of synergy (or conversely redundancy) in the coding. We paid particular attention to stimulus-dependent correlation because in its absence a pair of correlated cells with overlapping tuning would tend to interact redundantly and, consequently, the number of neurons that could be usefully pooled would be limited. The extent to which neurons interacted synergistically was found to be determined by this istimulus-dependent correlationî component of the information. We found that for orientation coding, stimulus dependence of correlation counteracts the redundant contributions due to overlapping tuning and the average level of correlation, leading to summation of information across neurons that is unconstrained by correlation effects (cf Zohary et al 1994). For the coding of contrast (which provides a natural control for this situation), the result is quite different, with correlation effects in this case leading to redundancy.

### Downward biased estimator of spike timing information

Sunday Poster –S16

The University of Manchester, Manchester, UK <u>m.montemurro@manchester.ac.uk</u>, riccardo.senatore@postgrad.manchester.ac.uk

A fundamental question in Neuroscience is to understand what features of the neural response carry information about external sensory stimuli. The most traditional hypothesis about the neural code is that the neurons represent stimuli by the total number of spikes fired in a certain post-stimulus time window. However, there is increasing evidence that precise spike times convey substantial extra information that is not available in spike counts alone. It is a crucial issue in the problem of neural coding to understand in which circumstances and for which neural systems the precise spiking of neurons represents the prevalent coding mechanism. Information theory provides rigorous framework to assess the problem of neural coding. However, in order to elucidate at which times scales the nervous system conveys information, neural responses over long observation times must be analysed at fine time scales. This poses a serious technical challenge since the amounts of data usually gathered in experiments is often not enough to yield accurate information estimates. In particular, estimations of the mutual information from finite data samples suffer from an upward bias, and it is usually difficult to assess the sampling quality of the dataset. Here, we propose a new estimator of the mutual information that is downward biased, as follows. We decompose the mutual information into two contributing terms: one that only carries information found in the spike counts, and a second one that reflects the extra information gained by looking at the precise spike times. This second term carries almost all the bias in the estimation of Shannon information. In this paper we introduce a new way to compute this term which is much less biased than a direct procedure, and with its residual bias being negative rather than positive. This new estimator can be used to bracket the asymptotic value of the mutual information when used together with the standard direct estimator. This can be valuable in situations in which the goodness of the sampling is not known a priori. A tight bracketing will give a robust confirmation of an accurate estimate. Also, this is an important step because a report of significant extra Information in spike timing when using this new downward biased method will reliably indicate that the additional spike timing information reflects a genuine neuronal behaviour and is not an artefact of the analysis.

## Persistent Sodium is a Better Linearizing Mechanism than the Hyperpolarization-activated Current

Danielle Morel William Levy Monday Poster -M19

University of Virginia, Charlottesville, Virginia, USA

dmorel@virginia.edu, wbl@virginia.edu

In steady-state systems, one way to obtain linearized dendritic synaptic integration is by adding voltage-gated dendritic conductances to models of passive dendrites, which incorporate sodium and potassium dendritic conductances. The hyperpolarization-activated mixed cation (h) and the persistent sodium (NaP) channels are compared as linearizing mechanisms for dendritic synaptic integration. In this study, the persistent sodium channel model creates a well-defined area of linear synaptic input for low to moderate levels of synaptic activity (total active synaptic conductance ranging from 0.5-5nS). In the simplified model used, this corresponds to a steady-state membrane potential range of -69mV to -55mV. In contrast, a hyperpolarization-activated enhanced model only linearizes at very low levels of synaptic activity (0-2.4nS) corresponding to an equivalently short voltage range of -70mV to -65mV. A physiological operating range centered around -60mV is implied by Destexhe and Pare with firing thresholds, for in vivo cells, ranging from around -60mV to -55mV. Based on this information, the dendritic persistent sodium current emerges as the better linearizing mechanism because it operates within a physiologically relevant voltage range for neurons under synaptic bombardment.

Populations of cortical neurons in the high conductance state: steady state and transient behaviours	Resonance as an effective mechanism of dynamical stability in large microcircuits of spiking neurons	
Ruben Moreno-Bote Tuesday Poster – T26 Nestor Parga	Raul Muresan       Monday Poster – M15         Cristina Savin, Iosif Ignat       Frankfurt Institute For Advanced Studies, Center for Cognitive and Neural	
Center for Neural Science, New York, New York, USA	Studies, Frankfurt am Main, Germany raulmuresan@yahoo.com, csavin@gmail.com	
rmoreno@cns.nyu.edu, np2182@columbia.edu		
In this communication we study both the stationary and transient response properties of a large population of independent neurons with conductance based synapses subject to an intense background mimicking conditions found {\em in vivo}. In the steady state, we compare the predictions of a solution of a computational model (R Moreno-Bote and N Parga, 2005) with the predictions of more standard models. In the transient regime, we show that this solution can reproduce some aspects of recent findings in auditory cortex (Wehr and Zador, 2003 and Tan et al 2004). Besides, we compare our prediction of the bimodality of the firing probability with its experimental observation in V1 neurons (Carandini, 2004).	The dynamical stability of large networks of spiking neurons is still an important issue in computational neurosciences. Here we investigate the behavior of a recently proposed model of spiking neurons, namely the resonator neuron put forward by E.M. Izhikevich. We show that the model prefers low frequency stimuli, while it is being less sensitive to high input bombardment. Furthermore, we show that large microcircuits of resonating neurons can easily get self- sustained in the absence of any external stimulation. Such a self-sustained regime proves to be very stable and robust for a wide range of network parameters.	
Spike-timing dependent plasticity in balanced random networks         Abigail Morrison       Tuesday Poster – T79	Rama Natarajan, Quentin Huys, Peter Dayan, Richard Zemel Department of Computer Science, University of Toronto, Toronto, Canada <u>rama@cs.toronto.edu</u> , qhuys@gatsby.ucl.ac.uk	
Ad Aertsen, Markus Diesmann	We propose a theoretical framework for efficient representation of time-varying	
Bernstein Center forComputational Neuroscience, Freiburg, Germany	sensory information using dynamic population codes. Our approach is based on the hypothesis that for accurate perception and computation, it must be possible	
abigail@biologie.uni-freiburg.de, aertsen@biologie.uni-freiburg.de	for downstream neurons to readily extract correct estimates of stimulus states from the sensory input. Intuitively, optimal computational decoding must	
The balanced random network model attracts considerable interest because it explains the irregular spiking activity at low rates and large membrane potential fluctuations exhibited by cortical neurons in vivo. Here, we investigate to what extent this model is also compatible with the experimentally observed phenomenon of spike-timing dependent plasticity (STDP). Confronted with the plethora of theoretical models for STDP available, we re-examine the experimental data. On this basis we propose a novel STDP update rule, with a multiplicative dependence on the synaptic weight for depression, and a power law dependence for potentiation. We show that this rule, when implemented in large (10^5 neurons) balanced networks of realistic connectivity and sparseness (10^4 synapses per neuron), is compatible with the asynchronous irregular activity regime. The resultant equilibrium weight distribution is unimodal with fluctuating individual weight trajectories, and does not exhibit development of structure. We investigate the robustness of our results with respect to the scaling of the depressing increments. We introduce synchronous stimulation to a group of neurons and downnetwork that the documling of this group from the store of	recover most of the encoded information. However, we have recently shown that even in a fairly constrained and analytically tractable formulation of a dynamic setting, decoding correct estimates can be a difficult computational problem. Information carried by the spikes is only temporally relevant, and when the input spikes are noisy or sparse, it becomes necessary to maintain a spiking history to perform accurate inference at any given time. We posit a recurrently connected population of neurons that recodes the input representation such that each spike can be decoded independently in a causal manner, without referring to any spike history. Decoding is carried out by a computationally simple, biologically reasonable scheme that interprets spiking activity as representing a probability distribution over stimulus states. Coding then involves learning to generate an apposite representation that optimizes the fidelity of decoding. We evaluate the efficacy of the proposed coding scheme by assessing the capability of the simple decoder in extracting the available information.	
of neurons, and demonstrate that the decoupling of this group from the rest of the network is so severe that it cannot effectively control the spiking of other	Serial correlation of inter-spike intervals in cortical neurons	
<ul><li>Modeling Spike-Frequency Adaptation in an Awake Cortical Network</li></ul>	Martin Nawrot Sunday Poster –S27 Clemens Boucsein, Victor Rodriguez-Molina, Sonja Gruen, Stefan Rotter Neuroinformatics, Free University Berlin Barrestrin Contract Computationeal Neuroscience, Barlin Cormony	
Eilif Muller Sunday Poster – S26	Bernstein Center Computationael Neuroscience, Berlin, Germany nawrot@neurobiologie.fu-berlin.de, boucsein@biologie.uni-freiburg.de	
Johannes Schemmel		
Karlheinz Meier	Renewal point processes are prominent models to describe the spiking of neurons. A renewal model assumes that the inter-spike intervals (ISIs) between	
Kirchhoff Institute of Physics, Heidelberg, Germany	successive action potentials are independent and identically distributed. We investigated serial interval statistics of spike trains recorded from cortical	
emueller@kip.uni-heidelberg.de schemmel@kip.uni-heidelberg.de	neurons in two different experimental settings under stationary conditions, and tested the mutual independence of ISIs. First, we performed a set of in vitro	
We show that the five-dimensional master equation for conductance-based integrate-and-fire neurons with spike-frequency adaptation and refractory mechanisms recieving a sufficiently strong but balanced barrage of Poisson inputs can be well approximated by a two-dimensional master equation by essentially neglecting membrane potential dynamics. Negative inter-spike interval correlations and transient population responses for the simplified model	whole-cell patch clamp experiments in layer 5 pyramidal neurons of neocortex, which were continuously stimulated by means of somatic noise current injection. Input currents were designed to mimic stationary and uncorrelated input from large pools of excitatory and inhibitory neurons. Second, we analyzed in vivo intracellular recordings of spontaneous activity in neocortical neurons of the anesthetized rat. We found a general tendency for weak and negative first order serial interval correlations in all neurons. The correlations of neighboring intervals were small with an average of approx0.05 in vitro and of -0.2 in vivo, and significantly different from zero in about 50% of all	

essentially neglecting membrane potential dynamics. Negative inter-spike interval correlations and transient population responses for the simplified model are shown to be in excellent agreement with the full system. These models exhibit filtering properties similar to a high-pass filter and transient responses at step stimuli which contribute to the evocation of synchronous bursts for weak changes in stimulation in balanced sparse coupled networks of inhibitory and spike-frequency adapting excitatory integrate-and-fire neurons characterizing a local circuit of cortical layer IV.

tested spike trains. No significant serial correlation of higher order was found. Our results

suggest an abstract point process model in which the spike probability at any given time

effect of serial correlations on statistical quantities such as interval and count variability. Supported by the German Federal Ministry of Education and Research (BMBF, grants

01GQ0413 to BCCN Berlin and 01GQ0420 to BCCN Freiburg).

indicate that cortical pyramidal neurons are not compliant with a simple renewal model. We

takes into account the previous spike train history up to the penultimate spike to account for the negative 1st order serial correlation. This model provides a more accurate description of spontaneous spiking in cortical neurons than the simple renewal model. We discuss the

Imaging epileptiform activity in brain slices of entorhinal cortex and hippocampus	Document retrieval from a citation network of neuroscience articles by continuous-attractor dynamics
Theoden NetoffTuesday Poster – 79Tilman Kispersky, John WhiteBoston University, Boston, Massachusetts, USAtnetoff@bu.edu, tilman@bu.eduEpilepsy is identified by two neuronal behaviors: short bursts of neuronalactivity, termed interictal bursts, and longer periods of neuronal activation,called seizures. Seizures are often thought of as an imbalance between excitationand inhibition allowing for the unchecked activation of the excitatory cells. Totest this hypothesis, we used optical imaging techniques to measure activityfrom neurons with single cell resolution in in vitro slices of hippocampus andentorhinal cortex bathed in 4-Aminopyridine (4-AP) to generate seizures.Simultaneous patch clamp recording from neurons were used to identifyepileptiform activity. Optical imaging revealed the propagation of activityduring seizures and interictal bursts in the entorhinal cortex and thehippocampus. Optical recordings revealed a strong activation of the superficiallayers of hippocampus and entorhinal cortex just prior to the seizure.Simultaneous electrical recordings show hyperpolarization of the patchedneuron, indicating a strong inhibitory component of the optical signal. Withevidence from this and other work, we hypothesize that strong activation of theinhibitory neurons ends with failure of the cells to fire, or effectively inhibitingthe excitatory network, resulting in the activation of the excitatory population,	Hiroshi Okamoto Yukihiro TsuboshitaSunday Poster -S47Fuji Xerox Co.Ltd, BSI, RIKEN Kanagawa, JapanBSI, RIKEN Kanagawa, Japanhiroshi.okamoto@fujixerox.co.jpOne problem overwhelming modern neuroscientists is a tremendous number of articles being published every year. Even for a narrowed topic, the number of articles to read often exceeds one's capacity. It is therefore crucial to know which articles are central or peripheral and which relations between articles are mainstreams or tributaries. We have developed a document-retrieval system to help this. In response to a user's query describing a research topic that he wants to survey, the system extracts a cluster of documents via continuous-attractor dynamics from a citation network of neuroscience articles. This cluster is organized in a scale-free network, which, if visualized, presents a birdis-eye view helpful for survey of previous studies related to the topic.A methodology for tuning nonlinear network models of parametric working memory
The Direction of Figure is Determined by Asymmetric Surrounding Suppression/Facilitation	Itsaso Olasagasti Tuesday Poster –T44 Mark S. Goldman
Haruka Nishimura Monday PM Oral Ko Sakai	University Hospital Zurich Wellesley College, Zurich, Switzerland
University of Tsukuba, Tsukuba, Japan	miren.olasagasti@usz.ch mgoldma2@wellesley.edu
haruka@cvs.cs.tsukuba.ac.jp sakai@cs.tsukuba.ac.jp The determination of the direction of figure plays a crucial role in the perception of objects in the real world (Finkel and Sajda, American Scientist, 1994). Physiological experiments have reported that a majority of neurons in monkeysi V2 and V4 is selective to the direction of figure (Zhou, Friedman & von der Heydt, J. Neurosci. 2000). These neurons are called Border-Ownership (BO) selective neurons, because the border ownership indicates which side of the border (figure side) owns the contour. To investigate the underlying cortical mechanisms of the BO selectivity, we have developed a computational model for BO determination based on the contextual modulation in early- to intermediate-level visual areas. In the model, BO-selective neurons have a facilitatory region extended to the preferred side of the neuron and a suppressive region extended to the other side, which is based on physiological reports that surrounding facilitation/suppression is located asymmetrically around the CRF with orientation specificity (Walker, Ohzawa, and Freeman, J. Neurosci, 1999). However, the roles of the facilitation and suppression have not been clarified. Specifically, it is uncertain what configuration of surrounding modulation is crucial for correct BO determination. In order to investigate the characteristics of Surrounding regions required for BO determination, we developed models of BO selective neurons with their surrounding regions generated randomly from a linear combination of Gaussian distributions. The model consists of three stages; (1) detection and normalization of contrast, (2) surrounding modulation and (3) determination of BO selectivity. We carried out the simulations of 300 model cells with various surrounding regions, and confirmed that most neurons reproduced highly consistent BO signaling for a variety of stimuli. We then analyzed the model cells that showed the perfect consistency in BO signaling among all stimuli presented, in order to reveal necessar	Persistent neural activity, or the sustained firing of a neuron after the driving input has disappeared, is a correlate of short-term memory and has been observed in several brain regions. How such persistent activity is maintained in a real experimental system is still not understood. A major barrier to achieving this understanding is in building realistic models that can be compared directly to experiment. Current models make a number of unrealistic assumptions, such as the neglect of nonlinearities or inhibition, in order to overcome difficulties arising in the treatment of the coupled nonlinear equations describing realistic networks. Here we present a methodology for overcoming these difficulties in nonlinear networks with excitatory and inhibitory neurons that show a continuum of levels at which persistent neural activity can be maintained. We first apply the framework to tune nonlinear rate models, and then show how these models can be converted into networks containing conductance-based spiking neurons. We first tune networks with a push-pull architecture that has been used to describe systems ranging from the oculomotor neural integrator, to working memory in prefrontal cortex, to decision making networks. In these networks neurons with the same sensitivity to the remembered stimulus are connected by excitation and those with opposite sensitivities are connected by inhibition. By considering an outer product connectivity between populations, each population can be represented by an average activity and the system becomes effectively four-dimensional. For this reduced dynamics we derive a simple condition for a one-dimensional attractor and use it to tune the connection strengths. If the tuning curves of the system are known we show more generally how networks with arbitrary connectivity can be tuned. In this case the tuning problem reduces to a simple curve fitting problem for each neuron whereby the known tuning curve sof the system are known we show more generally how networks with arbitrary connecti

Effect of sleep deprivation on oscillations in the human sleep EEG	Extraction of spatio-temporal primitives of emotional body expressions
Eckehard Olbrich Monday Poster – M102 Peter Achermann	Lars Omlor Monday Poster – M68 Martin A. Giese Hertie Institute for Clinical Brain Research
Max Planck Institute for Mathematics, Leipzig, Germany	University of Tuebingen, Germany, Tuebingen, Germany lars.omlor@tuebingen.mpg.de, martin.giese@tuebingen.mpg.de
olbrich@mis.mpg.de acherman@pharma.unizh.ch	Experimental and computational studies suggest that complex motor behavior is based on simpler spatio-temporal primitives. This has been demonstrated by
The human sleep EEG is characterised by the occurrence of distinct oscillatory events such as delta waves, sleep spindles, and alpha activity. Using a recently proposed algorithm for the detection of such events we investigated the effect of sleep deprivation on their incidence and properties. We found in particular that the increase in spectral power in the delta and in the alpha band after sleep deprivation can be traced back to an increase in the number of oscillatory events in delta or alpha band, respectively. We observed, however, large differences between the individuals. The analysis of the sleep EEG by studying oscillatory events is a promising tool to develop a more detailed understanding of the processes related to sleep regulation at the level of thalamocortical networks.	application of dimensionality reduction methods to signals from electrophysiological and EMG recordings during execution of limb movements. However, the existence of such primitives on the level of the trajectories of complex human full-body movements remains less explored. Known blind source separation techniques, like PCA and ICA, tend to extract relatively large numbers of sources from such trajectories, which are difficult to interpret. For the analysis of emotional human gait patterns, we present a new non-linear source separation technique that treats temporal delays of signals in a more efficient manner. The method allows the accurate modeling of high-dimensional movement trajectories with very few source components, and is significantly more accurate than other common techniques. Combining this method with sparse multivariate regression, we identified primitives for the encoding of
Dynamics of parameters of neurophysiological models from phenomenological EEG modelling	emotional gait patterns that match features, which have been shown to be important for the perception of emotional body expressions in psychological studies. This suggests the existence of emotion-specific motor primitives in
Eckehard Olbrich Monday Poster –M101 Thomas Wennekers	human gait. Oscillatory patterns in networks of asymmetrically coupled neurons using phase response curve
Max Planck Institute for Mathematics, Leipzig, Germany	Sorinel Oprisan Tuesday Poster – T39
olbrich@mis.mpg.de thomas.wennekers@plymouth.ac.uk	Ana Oprisan College of Charleston, Charleston, South Carolina, USA <u>oprisans@cofc.edu</u> , aoprisan@uno.edu
We propose a method, which allows to detect and model the typical oscillatory patterns of EEG data, but is capable of further quantifying processes on slower (< 1 Hz) time scales. These might reflect modulatory influences on the rhythm- generators causing waxing and waning oscillatory patterns (gamma, delta) or their appearance and disappearance (e.g., the 4-second "period" of sleep spindle occurrence). The slow parameter dynamics may yield additional insight into properties of the generating neural circuits. As a first step we restrict ourselves to linear (AR-)models with time dependent parameters, but a general framework could also use state space models. Systems described by such linear models can be interpreted as a set of coupled stochastically driven oscillatory with time dependent frequencies and damping. Specific oscillatory patterns show up in the data, when the damping becomes smaller than an appropriately defined threshold. The method has recently been applied to the characterisation of sleep oscillations in EEG. It is an open question to which extent the estimated frequencies and dampings correspond with true properties of oscillatory	Experimental and theoretical studies have shown that the amount of phase resetting produced in a neural oscillator depends not only on the stimulus timing, but also on its shape as determined by the characteristics of the synaptic coupling. In this study, we focused on predicting the firing patterns generated by a ring of two model neurons coupled by synapses characterized by variable conductances and time constants. Systematic exploration of the four-dimensional parameter space of synaptic conductances and time constants of an all-to-all asymmetrically coupled network of two neurons revealed the coexistence of multiple attractors among which we distinguished: antiphase modes, synchronous modes, and phaseless regions. Identifying neuronal assemblies with local/global connectivity with scale space spectral clustering Karim Oweiss Due Veri Cherit
eigenmodes in the underlying networks. The present study tests this relationship using simple neural network models to generate artificial data with controllable properties. We found that the method in this simple case detects the changes of the eigenfrequencies of the network induced by the parameter changes.	Rong Jin, Yasir Suhail Electrical and Computer Engineering Dept., East Lansing, Michigan, USA <u>koweiss@msu.edu</u> , rongjin@msu.edu
	Simultaneous recording of large-size neuronal ensembles with high-density microelectrode arrays (MEAs) is becoming a common trend in studying systems
Emergent dynamic behaviour in rate controlled chaotically driven neuronal models	neuroscience. Despite rapid advances in MEA fabrication technology, the identification of clusters of neurons with correlated spiking activity from the observed spike trains is a nontrivial problem. We propose a nonparametric
Tjeerd olde ScheperTuesday Poster -T27	analysis method to identify clusters of functionally interdependent neuronal populations, independent of the time scale at which they may be maximally
Department of Computing, Oxford Brookes University Oxford, UK	correlated. First, a multiscale representation of the spike trains is obtained using a Haar transformation. This allows the discrete event process of the spike train to be mapped to a scale space. In that space, each neuron is represented as a point object and connects to other
tvolde-scheper@brookes.ac.uk	neurons with a vertex that depends on a similarity measure. The similarity measure RXY between any given pair of neurons X and Y consists of an arbitrary defined statistic. When
Using a modified Hindmarsh-Rose type system with a controlled chaotic drive, different emergent behaviour can be shown in a mini-network with varying periodic input. The mini-network will respond differently purely on the basis of different input frequencies. The emergent dynamic behaviour is the result of the interaction between the input and the internal controlled chaotic drive.	Pearson correlation is used, the resulting measure expresses the correlation of the firing rates between the two neurons at each time scale. This may indicate the strength of their synaptic connectivity. On the other hand, when mutual information is used, the resulting measure expresses the information that both neurons may be receiving from a common input. The graph representation of the spike trains enables recently established graph partitioning theory and data mining techniques to be applied. Clustering neurons is subsequently undertaken using a probabilistic spectral clustering algorithm that simultaneously maximizes cluster aggregation based on the similarity measures as well as cluster segregation based on dissimilarity measures. We demonstrate the advantage of the proposed algorithm using non-homogeneous Poisson populations with distinct firing rate functions. We show that the proposed technique can map to a single cluster neurons in local circuits that may posses strong synaptic connectivity and respond with relatively fast temporal synchrony, as well as neurons in global circuits that receive common inputs that may exhibit slower temporal dependency arising later in the response.

Effect of the sub-threshold periodic cur synchronization of neuronal spiking act		On the timing precision needed to decode spi	
Mahmut Ozer	Tuesday Poster –T22	Stefano Panzeri Ehsan Arabzadeh, Mathew Diamond	Sunday AM Oral
Muhammet Uzuntarla	Tuesday Poster –122	Ensañ Araozaden, Matnew Diamond	
Sukriye Nihal Agaoglu		The University of Manchester, Faculty of Life s.panzeri@manchester.ac.uk, ehsan@sissa.it	Sciences, Manchester, UK
Zonguldak Karaelmas University, Zongul	dak, Turkey	The precise temporal pattern of spikes of sensor	y neurons conveys substantial
mahmutozer2002@yahoo.com muzuntarla@yahoo.com		sensory information beyond that available in spi have focused on the temporal precision of this c the internal clockî within the spike train, i.e. the	ke count. Many previous studies ode, by studying the precision of
We investigate the effect of the subthreshol on the synchronization of neuronal spiking extension of the Hodgkin-Huxley model th We add the Gaussian white noise with zer subthreshold periodic current. In the abser variation of interspike intervals reveals the coherence resonance. We show that the re frequency for very small patch sizes while larger patch sizes. We also show that the r frequency disappears when the amplitude decreased. Then, phase property between the forcing is examined based on the phase pr We demonstrate that the timings of the spi phase of the stimulus. The observed phase positive phase of the periodic current force the spikes fire most frequently at negative all noise levels. We also show that increas subthreshold periodic forcing causes the p values, and eliminates differences in the p with different patch sizes.	g activity by using a stochastic hrough the Langevin approximation. o mean to the externally applied nee of noise, the coefficient of e novel phenomenon of intrinsic sonance is independent of the forcing it is dependent on the frequency for esonance effect dependent on the of the subthreshold forcing is the fired action potentials and the obability density of the spiking events. iking events concentrate on a specific locking behavior occurs on the ing for a small frequency range while phase as the frequency is increased at ing the intensity of the noise added to hase probability density to get smaller	the spikes that is needed to preserve all the infor train. However, it is not clear how such a spike a downstream neural system. In particular, it is information decoded depends on the precision of knowledge of when the spike pattern occurred v In fact, spike times are measured with respect to their information content may require some know example, decoding response latencies would new whereas decoding interspike intervals may not r signal. To better understand how information is crucial to know to what extent the decodable Im precision of these clocks. Here we develop a no algorithm that quantifies how spike timing infor of both the internal and external clock. To shed transmitted along the ascending somatosensory technique to extracellular recordings from gang cells in the rat whisker system. We show that, ir information is transmitted through a very precis 4ms). However, much looser information about is needed read out this code. Since such externa available to cortex through an afferent signal from	timing code could be decoded by not known how the amount of f the iexternal clockî, i.e., the vithin the course of a single trial. o stimulus onset; thus decoding wledge of the external clock. For ed a precise iexternal clockî, equire such precise external transmitted across neurons, it is formation depends on the vel information-theoretic mation depends on the precision light on how information is pathway, we applied the new lion and cortical somatosensory n both ganglion and cortex, e internal clock (~20-40 ms) l clock information could be
Neural bases of context dependent react cortex of monkey	tion times in the dorsal premotor	whisking, these results suggest that a spike timit transmitted across the somatosensory system.	
Pierpaolo Pani Giovanni Mirabella, Maurizio Mattia, Pao	<i>Monday Poster –M64</i> lo DelGiudice, Stefano Ferraina	3D mouse brain gene expression visualizatior level expression search	and image-based genomic-
University iLa Sapienzaî, Rome, Italy, Dip Farmacologia, Rome, Italy	e e	Sayan Pathak	Monday Poster M75
pierpaolo.pani@uniroma1.it, giovanni.mir	avenawumomar.u	Christopher Lau Lydia Ng	
Although properties of the objects with wh		Leonard Kuan	
own body vary over time, we are capable		Edward Lein	
Several evidences lead to the idea that the execution of an action play a key role in the	ne efficiency of our motor	Michael Hawrylycz	
performance. To explore the neural correla one monkey (Macaca mulatta) to perform		sayanp@alleninstitute.org chrisl@alleninstitute.org	

monkey was required to execute arm reaching movements, but respect to the

control task either we provided him a different amount of prior information or we changed the cognitive context in which he was operating. We found that

changing the experimental conditions remarkably affect the RTs of the monkey.

Such a clear effect at behavioral level is likely to be driven by different patterns

while the animal was performing the task, we recorded both single unit activity

(SUA) and local field potential (LFP) simultaneously from 7 microelectrodes

implanted in the left dorsal premotor cortex. Our novel theoretical approach

allows to predict several time-dependent properties of the spiking collective

activity (in particular its power spectrum), and to link them to the pattern of

connectivity both inside the module, and between the latter and other neural

activity, the energy peaks at frequencies proportional to the mean spiking emission rate, and/or at frequencies determined by the characteristic times

(effective delays) of the interaction among neurons. A faithful experimental

estimate of the neural population activity should allow to formulate hypotheses

about the collective dynamics underlying the observed data. SUA does not seem

adequate; a tentative suggestion is to look for signs of population activity in the

raw signal from extra-cellular field potentials. We attempt such an approach in order to relate the LFP recordings to the SUA and complement it to formulate hypotheses on the ifunctionalî role of interactions between the neural populations involved, at time scales not accessible to brain imaging techniques. Here we present preliminary results obtained from the analysis of SUA and of LFP indicating the existence of a different contribution of those signals to the correlation between the dynamic of response preparation and the neural activity

immediately preceding the start of the movement.

populations with which it interacts. Depending on the level of noise in the neural

of brain activity. To link motor brain activity to the behavioral performance,

Advances in high-throughput genomic sequencing technologies, and robust image processing based bioinformatics tools are enabling neuroscience to approach genomic scale problems. The Allen Institute aims to map the approximately 24,000 genes of the mouse genome with anatomic specificity. The complexity and quantity of information derived from the large collection of generated images (20-50 images per gene) requires creation of databases and virtual or online workbenches providing analytical tools and models. To achieve this, there is a need to develop specific methods for comprehensive expression visualization in three dimensions and analyze gene/protein expression patterns. Similar to conventional genomic sequence bioinformatics tools, these efforts are needed to develop approaches that enable meaningful retrieval of expression patterns via online search methods. In this presentation, the algorithms used to map expression patterns automatically in three dimensions, the methods developed to visualize gene expression data interactively in three dimensions, and the development of a searchable database exposed at our institute website (http://www.brain-map.org) will be presented. We will present preliminary results from our current efforts to cluster expression patterns in 3D reconstructed in situ hybridization data.

Impact of spike sorting errors on higher-order correlations		Temporal relationships between cell pairs in integrate-and-fire networks		
	Antonio Pazienti Sonja Gruen	Tuesday Poster – T70	Jonathan Peelle Vogels Vogels Larry Abbott	Tuesday Poster – T53
	Neuroinformatics, Free University Berlin Bernstein Center for Computat Neuroscience, Berlin, G	ermany	Brandeis University, Waltham, Massach	usetts, USA
antonio.pazienti@neurobiologie.fu-berlin.de gruen@neurobiologie.fu-berlin.de		peelle@gmail.com vogels@brandeis.edu		
	Multiple single-unit recordings offer the chance to deter to identify the network composition and functions. To activities from extracellular recordings spike sorting is variety of sorting techniques are meanwhile available, is sorting errors are hard to avoid. These errors either appridentification of spikes (false negatives, FNs), or as assist wrong units (false positives, FPs). A few studies estima	retrieve the single neuron applied. Although a t became clear that ear as failures in the ignments of spikes to	Interactions between neurons that are bo useful for performing a wide variety of t coding, memory, and motor control. Alth that supports such activity (Abeles 1991; 1993; Ikegaya et al., 2004; Leonardo & I to present models of neural networks is p existence of temporal relationships betw	asks, including aspects of sensory hough there is experimental evidence ; Abeles, Bergman, Margalit, & Vaadia, Fee, 2005), the relationship of such data poorly understood. We investigated the

found that they are in the range of 10% or even more (Wehr et al (1999), Harris et al (2000), Wood et al (2004)). However, there are only very few studies on how such errors affect subsequent analyses of such data (besides Bedenbaugh & Gerstein (1997), Gerstein (2000), Bar-Gad et al (2001)). Our research focuses on the evaluation of the influence of FN and FP sorting errors on correlation analysis between spike trains, in particular onto the unitary event analysis (UE; Riehle et al (1997), Gr n et al (2002a,b)). UE analysis detects the presence of conspicuous spike coincidences in multiple parallel spike recordings and evaluates their statistical significance. In a previous study we introduced a probabilistic model that allows us to study the effect of sorting errors onto correlation between simultaneous spike trains. We found for systems of two neurons that the significance of pairwise correlation is a decreasing function of the error rates and always underestimates the underlying original correlation (Pazienti & Gr.n (2005), submitted). Here we extend the analysis to the case of correlations of higher-order, i.e. to correlations between three (or more neurons) that cannot be explained by lower order correlations. E.g. in the case of three simultaneously observed neurons, triple correlations may exist between all three neurons or alternatively pair correlations, or even a mixture of those. We report on spike sorting errors in the case of three simultaneous neurons, i.e. the simplest system to study the impact on higher-order correlations. We specifically address the question of the influence of spike sorting errors onto the occurrence and significance of coincidence patterns of various complexities, if a pattern of a specific order is inserted. Funded by the Volkswagen Foundation and the Stifterverband f r die Deutsche Wissenschaft.

## A Hardware based Brain Stem Sub-Nucleus Model for Brain-Based Robotic Experimentation

Martin Pearson Chris Melhuish Ben Mitchinson Tony Prescott	Sunday Poster –S55
Bristol Robotics Laboratory, Bristol, UK	
martin.pearson@uwe.ac.uk chris.melhuish@uwe.ac.uk	
An embedded, hard-real-time, 'spiking' neural netwo	~

An enheaded, hard-rear-fine, spiking neural network indee of shistry processing in the rat trigeminal sensory complex is presented. This forms part of a biologically inspired artificial whisker sensory system to be implemented and tested using a mobile robotic platform. An existing artificial active whisker and its associated Follicle Sinus Complex model has been used to generate biologically plausible, real-time tactile response spike trains. This on-line stimulus has been processed using a proposed neural network model of a spatial decoding operation performed partially in the trigeminal sensory complex of a rat. The emphasis of this work is that the model has been developed by computational neuroscientists using software on conventional personal computers and then ported directly into an embedded, massively parallel hardware neural processor with a guaranteed hard-real-time performance. This allows us to evaluate the validity and robustness of any neural network models as they perform in the real-world. integrate-and-fire neurons with excitatory and inhibitory synapses. The network architecture involves randomly chosen connections between cells, with each cell having a 1.5% chance of synapsing onto any other cell in the network. When network parameters are appropriately tuned, this network produces selfsustained asynchronous firing (Vreeswijk & Sompolinsky, 1996, 1998; Brunel, 2000; Mehring, Hehl, Kubo, Diesmann, & Aertsen, 2003; Lerchner, Ahmadi, & Hertz, 2004; Vogels & Abbott, 2005). To determine whether such a randomly connected network is capable of producing correlated activity between pairs of cells, we calculated cross-correlations between 15 cells and all possible 9,999 other cells. To correct for chance correlations, we subtracted cross-correlations computed for the same original cells and the other cells' shuffled data. We found a large number of large peaks in these correlograms, indicating significant correlations between cells. In our network, any single cell on its own is incapable of strongly influencing any one of its postsynaptic targets because each cell receives approximately 150 inputs, creating too much noise for a single input to have a large impact. Because of this limitation, relationships between any two cells must be facilitated by intermediary cells, which by acting together can reliably influence a downstream cell's firing rate. It does not appear that any postsynaptic cell's firing is caused by the same set of presynaptic inputs. Instead, some proportion of presynaptic inputs fire to alter postsynaptic activity, but the cells making up this proportion are constantly changing. Our results support the idea that reliable relationships in randomly-connected networks arise from network-level activity.

# An efficiency razor criteria for model selection and adaptation in the primary visual cortex

Laurent Perrinet

Monday Poster - M94

INCM / CNRS Marseille, France

laurent.perrinet@incm.cnrs-mrs.fr

We describe the theoretical formulation of a learning algorithm in a model of the primary visual cortex (V1) and present results of the efficiency of this algorithm by comparing it to the Sparsenet algorithm (Olshausen, 1996). As the Sparsenet algorithm, it is based on a model of signal synthesis as a Linear Generative Model but differs in the efficiency criteria for the representation. This learning algorithm is in fact based on an efficiency criteria based on the Occam razor: for a similar quality, the shortest representation should be privilegied. This inverse problem is NP-complete and we propose here a greedy solution which is based on the architecture and nature of neural computations (Perrinet, 2006). We present here results of a simulation of this network of small natural images (available at <a href="http://incm.cnrs.nrs.fr/perrinet/learn/">http://incm.cnrs.nrs.fr/perrinet/learn/</a> ) and compare it to the Sparsenet solution. We show that this solution based on neural computations produces an adaptive algorithm for efficient representations in V1.

Coding By Precise Timing in the Somatosensory Thalamus		Parameter estimation for neuronal signaling models: Deterministic and stochastic in silico data	
Rasmus Petersen	Monday Poster –M91		
Marcelo Montemurro		Antti Pettinen Monday Poster – M25	
Stefano Panzeri		Tiina Manninen, Olli Yli-Harja, Keijo Ruohonen, Marja-Leena Linne	
Miguel Maravall			
		Tampere University of Technology, Institute of Signal Processing, Tampere,	
Faculty of Life Sciences, University of Manchester		Finland	
Manchester, UK		antti.pettinen@tut.fi, tiina.manninen@tut.fi	
r.petersen@manchester.ac.uk		We are interested in benchmarking and developing automated parameter	
m.montemurro@manchester.ac.uk		estimation methods for neuronal signaling models. The results of our previous	

One of the fundamental questions in neural coding is whether the basic coding unit of neuronal spike trains is the individual spike or a correlated spike pattern. We investigated this issue using the rat vibrissa system as an experimental model. We recorded the responses of single units in the somatosensory thalamus to white noise deflection of a ratis vibrissae and analysed the spike trains using information theory. To assess the role of spike timing, we compared the information conveyed the total information in the spike train to that conveyed by the number of spikes within a time interval of upto 60 ms. We found that the spike timing code conveyed on average 12 bits/sec ñ an order of magnitude more information than the spike count code. To assess the role of correlated spike patterns vs that of individual spikes, we compared the total spike train information to that conveyed purely by firing rate modulations. Remarkably, firing rate accounted for 93% of the total spike train information, on average. In sum, these data indicate that the essence of the thalamic neural code is the precise timing of individual spikes.

### Spike-Triggered Covariance Analysis Of Neuronal Responses to Dynamic Whisker Stimulation

Rasmus Petersen Monday Poster – M93 Marco Brambilla, Miguel Maravall, Stefano Panzeri, Marcelo Montemurro

Faculty of Life Sciences, University of Manchester, Manchester, UK

r.petersen@manchester.ac.uk marco.brambilla@manchester.ac.uk

A basic aim of neural coding research is to understand how the probability of a neuron firing a spike depends on sensory stimuli. We addressed this issue by carrying out a white noise analysis of neurons in the somatosensory thalamus of the rat. We recorded the responses of single units to deflection of the vibrissae and analysed the resulting spike trains using reverse correlation. A neuronis stimulus-response relationship can be described by a linear-nonlinear model. The stimulus is convolved with one or more filters and the resulting filter coefficients combined via a tuning function whose output approximates the instantaneous firing rate. We estimated the filters and tuning function characteristic of each neuron by spike-triggered averaging and spike-triggered covariance analysis. We found two types of neuron. One type was remarkably simple and well-characterised by a single filter model, where the filter was often approximately a velocity filter. Covariance analysis revealed extra filters but they added little information to that available from the spike-triggered average. However, other neurons had strongly non-linear tuning functions and could only be modelled accurately by a multi-filter model. In sum, the response of some thalamic neurons could be described by a remarkably simple single filter model; others required a more complex, multi-filter description.

#### study indicate that when the number of parameters to be estimated is small, the stochastic, global, parameter estimation methods, such as evolution based algorithms, generally outperform the deterministic, local methods, such as the Newton method. The aim of this study is to perform estimation tests with a larger set of unknown parameter values (20 parameters). Based on the results of the previous study, five methods are selected and their performance is compared using both deterministic and stochastic in silico data as the training data. The selected methods are Simulated Annealing (SiA), Genetic Algorithm (GA), Evolutionary Programming (EP), Multistart (MS), and Levenberg-Marquardt (L-M). The first four methods are global, stochastic methods, and the last, Levenberg-Marquardt, is local, deterministic method. The in silico training data is generated by simulating either the deterministic or the stochastic differential equation model of our test case, the PKC pathway. Stochasticity in biochemical networks arises because small numbers of chemical species may be involved and consequently chemical reactions are composed of random collisions between individual chemical species. The PKC pathway, that is used here as the test case, is a part of larger signal transduction network that has been shown to be involved for example in synaptic long-term potentiation and depression of neurons. The model, which describes the transformation of inactive PKC to active PKC, contains 15 interacting molecules, and is connected by 10 reversible reactions (mass-action kinetics). When estimating the full set of 20 parameter values of our test case at a time, it can be concluded that the five tested methods (SiA, GA, EP, MS, and L-M) can perform well in estimating a larger number of parameter values. However, the performance is strictly dependent on both the initial values of each parameter and the constraints for the parameter search space, indicating that good a priori information is required, thus making the task non-trivial. In future we will develop and apply more sophisticated methodology to address these problems. Our preliminary tests with stochastic in silico data show that in principle it is possible to perform estimation tests using more realistic data. Further studies are needed to improve the performance of the optimization methods when using stochastic data.

#### Model-based optimal decoding of neural spike trains

Jonathan Pillow Liam Paninski Sunday Poster –S21

Center for Neural Science, NYU, HHMI, London, UK pillow@gatsby.ucl.ac.uk, liam@stat.columbia.edu

One of the central problems in computational neuroscience is that of understanding how stimulus information is encoded in neural spike trains. Decoding methods provide an important tool for addressing this problem, allowing us to explicitly read out the information contained in a set of neural responses. Here we introduce several decoding methods based on point-process encoding models of the neural response (i.e. forward models that predict spike responses to novel stimuli, and which also account for spike-history dependence and functional coupling between cells). These models have concave loglikelihood functions, allowing for efficient fitting with maximum likelihood. Moreover, they allow us to perform optimal decoding of responses using the likelihood of observed spike trains under the model. Here we present: (1) a tractable algorithm for computing the maximum a posteriori (MAP) estimate of the stimulus, or the most likely stimulus to have generated a particular response, given some prior distribution over the stimulus; (2) a Gaussian approximation to the posterior distribution, which allows us to measure the fidelity with which various stimulus features are encoded; (3) a method for computing the Bayes optimal estimate of the stimulus (the posterior mean, which achieves minimal mean-squared error); (4) the ability to marginalize over an entire distribution of stimuli, providing an optimal framework for {\em change-point analysis}, such as detecting the time at which the stimulus undergoes a change in variance; and (5) a tractable method for estimating the mutual information between a population spike train and a high-dimensional stimulus. We show several examples illustrating the performance of these estimators with simulated data.

NeuroXidence: Cross-validation of task relat reported by Riehle et al. (1997)	ed Joint-spike activity	A Model of Angle Selectivity Develo	opment in Visual Area V2
reported by Rieme et al. (1997)		Alessio Plebe	Monday Poster – M55
Gordon Pipa Alexa Riehle, Sonja Gruen Max-Planck Institute for Brain Research Frankfurt Institute for Advanced Studies, Frank	Tuesday Poster –T71	Department of Cognitive Science Univ Catania, Italy	v. Messina
pipa@mpih-frankfurt.mpg.de, alexa.riehle@inc		alessio.plebe@unime.it	
In the recent years the discussion of the assemb controversial. On the one hand evidence for fine validation of the assembly hypothesis is accume are still concerns about the analysis techniques existence of the fine-temporal coordination acre spiking activities. One of the key findings that s was found in recording from primary motor cor involved in a delayed pointing task (Riehle et al joint-spike activity of simultaneously recorded to the state of the s	e-temporal structure and alating. On the other hand there used to demonstrate the biss simultaneously recorded supports the assembly hypothesis tex of behaving monkey 1. 1997). It was shown that excess neurons occurs dynamically at	responses is explored, using an artifici called LISSOM (\textit {Laterally Inter Map}) includes excitatory and inhibiti two LISSOM maps are arranged as V classical domains of orientation select neurons become sensitive to pairs of a	ivity will develops, while in V2 several ingled segments.
behaviourally relevant points in time. The analy Unitary Event analysis method (UE; Gr, n et al.		Precise and efficient discrete time no	eural network simulation
present a cross validation of results presented in application of a new method, called NeuroXide parametric and considers the complete auto-stru- significance of joint-spike events. Unitary even	Riehle et al, 1997 by nce. The method is non- acture of the data to estimate the	Hans Plesser Abigail Morrison Sirko Straube Markus Diesmann	Sunday Poster –S51
NeuroXidence method yield the same results fo although the underlying assumptions in respect temporal structure of the spike trains differ cons assumptions inherent of analysis methods onto	to stationarity requirements and siderably. The influence of	Dept. of Mathematical Sciences and T Norwegian University of Life Science	
results are discussed.	the occurrence of faise positive	hans.ekkehard.plesser@umb.no abigail@biologie.uni-freiburg.de	
Modulation of excitability in CA1 pyramidal EC and CA3 inputs Eleftheria Kyriaki Pissadaki Panayiota Poirazi IMBB-FORTH, Vasilika Vouton, Hellas ekpissad@imbb.forth.gr, poirazi@imbb.forth.gr	Tuesday Poster –T10	widely: event-driven and time-driven. neurons are effectively decoupled exc state of a neuron is updated only wher simulation algorithm can "hop" from s	obtained if these algorithms are classes of simulation schemes are used Event-driven schemes exploit the fact ept when they exchange a spike. Thus, n it either receives or emits a spike, and spike to spike, entailing a global spike
Hippocampal CA1 pyramidal neurons receive extrahip inputs. EC projections converge at Stratum Lacunosur Temporoammonic Pathway (TA) while the Schaffer C projects to the Stratum Radiatum (SR) of the CA1 fiel Subiculum and to the deeper layers of EC. The SC pat input to CA1 cells whereas the TA pathway provides a interplay between the two pathways can trigger differe The relative temporal placement of the stimuli of seems to efficiently modulate the excitability of Specifically, the excitatory effect of SC inputs i preceded by SLM stimulation within a well defi phenomenon is referred to as the Spike Blockin	n Moleculare (SLM) via the ollateral Pathway (SC) from CA3 d. CA1 neurons in turn project to the hway serves as the primary excitatory potent inhibitory modulation. The int patterns of neuronal responses. conveyed by the two pathways CA1 pyramidal neurons. s greatly attenuated when ined time-window. This	neuron will spike next. For some neur efficiently. Time-driven simulation sc grid. They are easier to implement that neuron models to predict their next sp spikes are forced to the grid; this may Event-driven schemes are often percei- ones, since the former update the state (or a spike is emitted), while the latter (approx 0.1ms). In realistically sized r receives some 10^4 inputs, the total in	hemes update neuronal states on a time in event-driven schemes and do not require, but incur an accuracy penalty as significantly distort network activity. ived as more efficient than time-driven to f a neuron only when input spikes arr update each neuron at short intervals
Schuman, 1999 found that spike blocking effica he GABAb signalling pathway, whereas in the spike blocking was almost abolished. In this we contribution of the GABAb receptor on the afor refined version of a previously published multic pyramidal cell. We also investigate to what exte	ccy has a temporal relation with presence of GABAb antagonist ork, we investigate the rementioned phenomenon using a compartmental model of a CA1	will then be around 0.1ms also in the or moreover has additional overhead for Therefore, it is not clear a priori wheth scheme will have better performance. implementations of the same integrate globally time-driven simulation schem	case of event-driven simulation, which event management (global spike queue her an event-driven or a time-driven We present and analyse three -and-fire neuron model in the context of he. We show that it is possible to combi
he clustering of synaptic inputs within the deno hat in addition to a temporal regulation, the arr- provides a location-dependent modulation of ex- can selectively induce spike blocking or spike e modulation could provide a cellular mechanism	angement of synaptic contacts citability by the EC input, which nhancement. This form of	the level of the individual neuron, ach machine limits. We show that if the ne even local storage and sorting of incor	euron has linear subthreshold dynamics
and retrieval processes. Alternatively, this excit subserve the consolidation of strong, TA-media support a role for strong, patterned synaptic in	ability modulation could ted stimuli. Experimental data	than a traditional grid-constrained imp	blementation for a wide range of realistic chemes have an advantage in reproduct

support a role for strong, patterned synaptic input from the TA pathway in initiating the transport of new mRNA transcripts to the synapse and the local synthesis of identified proteins. Furthermore, it has been experimentally shown that the TA pathway is essential for the consolidation of long term spatial memory. Thus, it is conceivable that synaptic clustering provide a suitable substrate for the enhancement of protein synthesis in SLM, where patterned strong stimulation occurs, in order for long-term memories to be stabilized-consolidated. At the same time this enhancement of neuronal excitability might contribute to long-term memory storage by signifying the importance of the incoming stimulus and propagating the response to higher brain regions.

macroscopic dynamical features such as synchrony.

#### Optimal signal in ligand-receptor models Improved stability and convergence with three factor learning Monday Poster -M78 Ondrei Pokora, Petr Lansky Bernd Porr Tuesdav PM Oral Institute of Physiology, Academy of Sciences, Prague, Czech Republic Tomas Kulvicius pokora@math.muni.cz Florentin Woergoetter lansky@biomed.cas.cz University of Glasgow, Department of Electronics & Electrical Engine Models for coding of odor intensity, especially the concentration and flux Glasgow, UK detectors and their variants, are investigated. We focus on the essential stage, the input-output relation, realized as a number (portion) of bound receptors in b.porr@elec.gla.ac.uk dependence on the signal level, concentration of odorant molecules in tomas@chaos.gwdg.de perireceptor (or external) space. Our models assume that the signal should be determined from the number (portion) of receptor-ligand complexes, where the Donald Hebb postulated that if neurons fire together they wire together. dependence on signal is realized through the input-output function (usually the However, Hebbian learning is inherently unstable because synaptic weights will logistic function). How the number of complexes can code the intensity of self amplify themselves: the more a synapse drives a postsynaptic cell the more the synaptic weight will grow. We present a new biologically realistic way of stimulation is analyzed using the statistical properties of the steady-state responses. The approach we use, is based on stochastic variant of the law of showing how to stabilise synaptic weights by introducing a third factor which mass action. The response, expressed as the input-output function, is assumed to switches learning on or off so that self amplification is minimised. The third be a random variable with a probability density function belonging to a factor can be identified by the activity of dopaminergic neurons in VTA which parametric family with the signal as a parameter. We consider different types of leads to a new interpretation of the dopamine signal which goes beyond the distributions of the response. The Gaussian distribution is not appropriate in classical prediction error hypothesis. some cases for its indefinite range and the symmetry. The Beta distribution seems to be more suitable. We use Fisher information as a measure how well the signal can be estimated from the response. Higher the Fisher information the better estimation of the corresponding signal can be achieved. Corresponding Functions of Distributed Plasticity in a Biologically-Inspired Control coding ranges, intervals of signal which can be well estimated from the System response, are defined. The point in which the first derivative of the input-output function is maximal in most models coincides with the point where is the John Porrill Sunday Poster - S58 maximum of the Fisher information. In some models, for example concentration Paul Dean, Sean Anderson, Mayank Dutia, John Menzies, Chris Melhuish detector with activation stage, these two points differ and the coding range Tony Pipe, Alexander Lenz, Thanushan Balakrishnan determined through the Fisher information is shifted in comparison with the one defined through the steepness of the input-output function. Department of Psychology, University of Sheffield, Sheffield, UK j.porrill@sheffield.ac.uk Time-scales in the interplay between calcium and voltage dynamics p.dean@sheffield.ac.uk

Biologically controlled movement is superior in certain respects to its robotic counterpart. An important potential source of this superiority is the brain's control algorithm, in particular the algorithm implemented by the microcircuitry of the cerebellum. We describe here the progress of a multi-disciplinary collaboration to evaluate cerebellar-inspired control architectures for the adaptive control of mobile robots. Our example problem is the calibration of the vestibulo-ocular reflex (VOR), a reflex which stabilises the eyes during head movements, for which the cerebellum is known to be essential. A puzzling feature of the cerebellar control network for the VOR is that it uses two sites of plasticity, one within the cerebellum itself and one in the brainstem, related to the neurons to which the cerebellum projects. We are examining the nature and function of this distributed plasticity with the following goals to i) characterise the properties of brainstem plasticity by electrophysiological recording ii) construct models of cerebellum and brainstem plasticity to investigate the computational properties of algorithms with brainstem plasticity iii) implement and evaluate biologically-inspired algorithms for the adaptive control of a robotmounted camera. These combined studies will help to identify the novel features of biological control that contribute to its stability and robustness. The fact that the cerebellar microcircuit is used in thousands of different contexts in biological control suggests that identifying the cerebellar algorithm will have widespread application to problems in robot movement.

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Gonzalo G. de Polavieja Srikanth Ramaswamy Fabiano Baroni Pablo Varona

Sunday Poster -S65

gonzalo.polavieja@uam.es srikanth.ramaswamy@uam.es

Widely acknowledged as the ëdirector ioní, the calcium ion Ca2+ controls excitability, neurotransmitter release and plasticity [Berridge, 1998]. Calcium entering from voltage-dependent channels or released from internal stores controls conductances responsible for slow afterhypolarization or depolarizing afterpotentials following spikes. These potentials, in turn, modify the neuronal firing. In effect, the slow dynamics of calcium and its interaction with the neuronís electrical responses is a form of short-term memory. This memory can be used, for example, as a delay in the computation of motion detection [Barlow, 1996], to adapt to stimulus statistics [Fairhall & Bialek, 2003, Arganda et al. 2006] or to intervene in synaptic integration by affecting the shape of backpropagating action potentials [de Polavieja et al., 2005]. Calcium is also a player in the global dynamics of the neuron. It contributes to generate complex patterns of spiking bursting-activity and can also affect the reliability of particular features of the electrical response [Baroni et al. 2005]. These two effects, short-term memory and a fundamental role in the single-neuron dynamics, make calcium a major player in the network dynamics. We therefore expect calcium to play a role in the regulation of rhythms in the inhibitory loops found in many central pattern generators, in adaptation to statistics or more generally in the processing of recurrent circuits. To further our understanding of the interplay between calcium and voltage dynamics, we have performed a statistical analysis of 50-100s long recordings of simultaneous calcium and voltage activity in sensory neurons, interneurons and motorneurons. This analysis reveals a different time-scale for this interplay.

Inhibitory Conductance Dynamics in Cortical Neurons During Activated States		Comparison of spiking neurons based on conductance space exploration of model neurons from two phyla	
Martin Pospischil	Monday Poster –M10	Astrid Prinz	Monday Poster – M6
Zuzanna Piwkowska		En Hong, Adam L. Taylor	
Michelle Rudolph			
Thierry Bal		Emory University, Department of Biology, Atlanta	a, Georgia, USA
Alain Destexhe		astrid.prinz@emory.edu, en.hong@emory.edu	
'UNIC', CNRS UPR 2191, Gif-sur-Yvette, France		Neuronal activity arises from the interplay of mem Although some channel proteins conducting these	5 1
martin.pospischil@iaf.cnrs-gif.fr		highly conserved, channels of the same type in dif	ferent animals (between and
zuzanna.piwkowska@iaf.cnrs-gif.fr		within species) can have different voltage-depende	encies and dynamics. What

During activated states in vivo, neocortical neurons are subject to intense synaptic activity and highamplitude membrane potential (Vm) fluctuations. These "high-conductance" states may strongly affect the integrative properties of cortical neurons. We investigated the responsiveness of cortical neurons during different states using a combination of computational models and in vitro experiments (dynamic-clamp) in the visual cortex of adult guinea-pigs. Spike responses were monitored following stochastic conductance injection in both experiments and models. We found that cortical neurons can operate in two different modes: during states with equal excitatory and inhibitory conductances, the firing is mostly correlated with an increase in excitatory conductance, which is a rather classic scenario. In contrast, during states dominated by inhibition, the firing is mostly related to a decrease in inhibitory conductances (dis-inhibition). This model prediction was tested experimentally using dynamic-clamp, and the same modes of firing were identified. We also found that the signature of spikes evoked by dis-inhibition is a transient drop of the total membrane conductance prior to the spike, which is only present in states with dominant inhibitory conductances. Such a drop should be identifiable from intracellular recordings in vivo, which would provide an important test for the presence of inhibitiondominated states. We discuss several methods to provide such an analysis. In conclusion, we show that in artificial activated states, not only inhibition can determine the conductance state of the membrane, but inhibitory inputs may also have a determinant influence on spiking. Future analyses and models should focus on evaluating the importance of inhibitory conductance dynamics from in vivo experiments. Supported by: CNRS, HFSP and the EU

#### Voltage Distributions of Stochastic Integrate-and-Fire Neurons Move in a Low Dimensional Space

Joanna Pressley Tuesday Poster – T28 Todd Troyer

University of Maryland, Washington DC, USA pressley@math.umd.edu, ttroyer@glue.umd.edu

We are interested in how simple integrate-and-fire (IF) neuron models respond to inputs that vary temporally in both amplitude and variance. Previous studies have focused on equilibrium solutions or linearizing perturbations around equilbrium to investigate the nonlinear response of a particular model. To develop a deeper understanding of the models' responses to more complex currents, we employ a probability density approach to study the firing rate of IF models. Using the Fokker-Planck equation, we simulate the probability density function (pdf) over membrane potential as an n-dimensional vector. As the external current's amplitude or variance changes, the pdf moves through an ndimensional space. Our aim is to reveal the true dimensionality of the movement and develop a reduced dimensional model of the response. To initiate a reduction of the model's response, principal components analysis was utilized to determine the number of dimensions needed to closely approximate the true movement of the pdf of voltages due to temporally varying inputs. We found that 3 dimensions are required to approximate the response to a step up in the amplitude of the external current. Continuing work focuses on varying the standard deviation of the noise, applying more complex patterns of inputs, and on finding the biological parameters that determine the dimension of the underlying response dynamics.

within species) can have different voltage-dependencies and dynamics. What does this mean for our ability to derive rules about the role of different types of ion channels in the spontaneous activity and response properties of neurons? Can results about the role of a particular type of ion channel in a particular type of neuron be generalized to other neuron types? We compared tonically spiking model neurons in two databases constructed by exploring the maximal conductance spaces of a crustacean stomatogastric ganglion (STG) model neuron and a rodent thalamocortical (TC) relay neuron model. Databases were constructed by allowing each independent maximal conductance (8 for the STG and 9 for the TC model) to take one of 6 values and simulating the spontaneous activity for each possible combination of conductances (1.7 million for the STG and 10 million for the TC model). The spontaneous activity produced by a conductance combination was classified as tonically spiking if it showed constant inter-spike intervals. We used dimension stacking (a visualization method) to show that although spiking neurons in both databases show distinct fast and slow subpopulations, these subpopulations are located in different subregions of conductance space, suggesting distinct fast and slow spike mechanisms in the two species. The most obvious differences between STG and TC spikers are related to the role of potassium currents in influencing neuronal behavior and spike frequency. The fast and slow STG spikers markedly differ in their maximal conductances for the delayed rectifier current I\_Kd: fast spikers tend to have high and slow spikers tend to have low levels of I Kd in the STG database. The opposite is true in the TC database for the related current I K2: fast TC spikers tend to have low levels and slow spikers tend to have high levels of I K2. The two neuron types from two different phyla thus arrive at qualitatively similar spike frequency distributions with slow and fast subpopulations through different biophysical mechanisms. Our results suggest that the role a specific type of membrane current plays in shaping a neuronís behavior may depend on the exact voltage dependence and dynamics of that current, and may be different depending on the properties of other membrane currents it is interacting with.

#### **Controlling Network Dynamics**

Tuesday Poster -T45

Kanaka Rajan Larry Abbott

Center for Theoretical Neuroscience, Columbia University New York, New York, USA

kr2208@columbia.edu lfa2103@columbia.edu

We explore mechanisms by which a set of constant inputs to a neural network can generated predictable and repeatable patterns of activity with complex dynamics. Model networks of firing-rate or spiking neurons can exhibit dynamic activity ranging from fixedpoint behavior to oscillations or chaos. These patterns of activity can play useful cognitive and functional roles (Amit, 1989). Taking advantage of this richness, however, requires control of network dynamics so that a desired form of activity can be called up when it is needed. We explore mechanisms by which such control can be exerted.

Timing is everything:	Donamine	signals in t	temporal	difference learning
I ming is crei jump.	Dopumme	Signais in .	comportai	uniter ence rear ming

Peter Redgrave	Sunday Poster – S81
Kevin Gurney	

Neuroscience Research Unit, Dept. Psychology, Sheffield, UK

p.redgrave@sheffield.ac.uk, k.gurney@sheffield.ac.uk

Most contemporary computational models of reinforcement learning in the basal ganglia assume that phasic dopamine signals represent a measure of the error term in a Temporal Difference learning algorithm. The reinforcement component of this error term is thought to derived from an assessment of appetitive reward provided by the external environment. In this way, the animal learns to select actions that maximise future appetitive reward. However, recent biological evidence suggests that, at the time of phasic dopaminergic signalling, the appetitive reward value of the event eliciting the dopaminergic response is largely unknown. Specifically, there is insufficient time between stimulus onset and the phasic dopamine response, to evaluate whether the stimulus was ërewardingí, ëaversiveí, or neutral. To accommodate this timing problem, we propose an alternative, biologically constrained hypothesis that the basal ganglia are, in part, configured to learn those events (irrespective of reward value) that are caused by the agent. The phasic dopamine inputs provide teaching signals that enable critical causative aspects of the multidimensional input representing context, goals, actions, and movements to be identified.

#### Are Biomedical Database Ontologies Enough: a Survey of Stroke Microarray Datasets

Kenneth Revett University of Westminster, Harrow School of Computer Science London, England

#### revettk@westminster.ac.uk

In this paper, we discuss the results of several DNA microarray experiments that were performed to gather information about differential gene expression profiles responsible for ischaemic preconditioning (IPC). We wished to compare the results of a series of experiments ñ culling together data that would provide a more comprehensive glimpse into a comprehensive set of differentially expressed genes that might reveal which genes are responsible for this phenomenon. Our analysis highlights several difficulties in this type of approach: i) inconsistent time series, ii) lack of a consistent threshold for a differential expression level, iii) inconsistency in changes in gene expression levels are reported, and iv) different types of ischaemic induction to name a few. The Microarray Gene Expression Database (MGED) community has spent a considerable effort in proposing and implementing a workable ontology for any type of DNA microarray experiment. If researchers comply with this standard, but fail to collaborate at the experimental level ñ then the efforts of the MGED community will be in vain. The philosophy here is that experimental protocols should be demonstrably consistent across laboratories ñ this includes not just annotation, but also experimental design, and data analysis techniques. We highlight these issues in this paper by presenting data on the gene expression profiles involved in IPC from various laboratories. The results from this inquiry indicate that researchers must collaborate more thoroughly with one another if data is to be shared in a truly global sense.

#### Selection in a model of striatum with fast spiking interneurons

Wood Ric Tuesday Poster -752 Humphries Mark, Overton Paul, Stewart Robert, Kevin Gurney University of Sheffield, Sheffield, UK ric.wood@sheffield.ac.uk m.d.humphries@sheffield.ac.uk

Recient modelling work, using simple leaky intergrate and fire neurons, has suggested that the microcircuitry of the striatum could act to impliment selection over a short spatal range in circuits of MS neurons, augmented by selection via fast spiking interneurons across larger distances. The model presented here expands this earlier work to show some limited selection in a network of spiking neurons. In addition the model presents a noval method of including gap junction in a particular class of spiking neuron introducted cy Izhikevich (2006).

Preparing for the German neuroinformatics node

Sunday Poster -S43

Raphael Ritz, Andreas Herz ITB, Humboldt-University, BCCN-Berlin, Berlin, Germany r.ritz@biologie.hu-berlin.de a.herz@biologie.hu-berlin.de

Novel experimental and computational techniques have led to major transitions in the neurosciences, all the way from the molecular to the system level. At the same time, more and more scientists are willing to share their data, analysis tools and computer models and have thus started a new research culture reflecting the open source philosophy. However, many of the data and computer programs already publicly available are not known to the general neuroscience community and other interested scientists. To overcome the problem, the Working Group on Neuroinformatics of the OECD Global Science Forum has issued a proposal to create an International Neuroinformatics Coordination Facility (INCF) which was positively endorsed in 2004 and which is currently being established in Stockholm, Sweden. One of INCF's central tasks is to set up an internet--based knowledge management system for all data relating to nervous system structure and function through a network of internet portals. Today, there are various levels at which portals, or more generally, web-accessible databases are set up and maintained: Laboratories: e.g., to keep control over which data should be made available to whom. Example: http://bernstein.biologie.hu-berlin.de/oel Local Communities: for distribution of information specific to a local community (e.g., talks, lectures, courses, ...) Example: http://www.bccn-berlin.de Distributed Specific Communities: for distribution of information specific to a specialized community. Example: http://nnss.neuroinf.de National Sites: to serve as a general access point providing an overview of a country's activities in the field. Example: http://bccn.neuroinf.de Now, the INCF's task is to provide guidance and support to get those individual sites interoperable. The national sites (hosted by the national nodes in terms of the INCF) are supposed to establish interoperability between the local sites on one hand and the global network on the other hand. In this contribution some problems encountered in realizing the network illustrated above as well as potential solutions will be discussed. Furthermore, current activities in Germany that let to several interoperable databases and web sites will be presented. Supported by BMBF.

#### Storage of Auditory Temporal Patterns in the Songbird Telencephelon

Patrick Roberts Roberto Santiago Claudio Mello Tarcisco Velho

Monday Poster -M73

Neurological Sciences Institute, Oregon Health & Science University Beaverton, Oregon, USA

robertpa@ohsu.edu robes@sysc.pdx.edu

The purpose of this project is to develop a quantitative model that explains how auditory patterns are stored in the songbird auditory forebrain, a candidate site for song perception and the formation of song auditory memories. Our objective is to identify the features of bird song that are used by the auditory forebrain to identify and distinguish memorized songs. The results of our model suggest biological mechanisms of temporal pattern prediction and the storage of higherorder patterns, where by higher-order, we mean the specific arrangement of syllables into song motifs (phrases) to reveal neural mechanisms of syntax.

Depolarizing, GABA-Mediated Synaptic Responses and Their Possible Role	Attention improves object discriminability in monkey area V4
in Epileptiform Events	

		David Rotermund	Sunday Poster – S2
Richard Robertson	Monday Poster –M13	Taylor Katja	
Kerstin Menne		Udo Ernst	
		Pawelzik Klaus	
Calif. State Polytechnic University, Pomona, California, USA		Kreiter Andreas	
neurocyclist1@aol.com, k.menne@gmx.net			

University of Bremen, Institute for Theoretical Physics Bremen, Germany

davrot@neuro.uni-bremen.de taylor@brain.uni-bremen.de

Attention is thought to improve processing of selected stimuli. It has been demonstrated that firing rates can be modulated by attention and that their enhancement can improve the signal-to-noise ratio (SNR) for discriminating stimulus features. We investigate effects of selective attention on object representation using recordings of local field potentials (LFPs). We trained 2 monkeys to attend to one of two sequences of objects, which were simultaneously presented in both hemifields. The task required the monkeys to identify the re-occurrence of an object previously presented in the attended hemifield. LFPs were recorded with an array of 36 epidural electrodes, covering parts of area V4 and V1, while the monkeys were performing the task. Analysis of object encoding was done with support vector machines trained on LFP wavelet coefficients, allowing to estimate the probability of correct classification of the objects actually present. Using all electrodes, we found a performance of up to 94% correct (1200 ms window, chance level: 17%), i.e. the LFP-data enabled nearly perfect object identification. Almost all stimulus-specific information was concentrated in the frequency range from 30 to 100 Hz. Classification on data from 5 electrodes covering V4 resulted in 52% performance for non-attended stimuli, and 63% for attended stimuli. This corresponds to a 31% performance increment above chance level. Classification of attention direction on LFP-signal from only one electrode located above V4 gave 75% performance (chance level: 50%). Furthermore we show that encoding improvement is specifically linked to shifts in spectral content, but not to increases in SNR. Our results show that attention improves encoding of visual stimuli in gamma-band neuronal activity. The high classification performance on objects and direction of attention suggests that LFP signals also from visual cortex could be useful for brain machine interfaces. Supported by the Deutsche Forschungsgemeinschaft (grant A7 and B5 in SFB 517) and BMBF (grant DIP METACOMP).

Dynamics of Moment Neuronal Networks

Sunday Poster –S17

Enrico Rossoni Jianfeng Feng Yingchun Deng

Sunday Poster -S66

Department of Computer Science, University of Coventry, UK

enrico.rossoni@gmail.com jianfeng.feng@warwick.ac.uk

A novel theoretical framework is developed for moment neuronal networks (MNN). Within this framework, the behaviour of the system of spiking neurons is specified in terms of the first and the second order statistics of their interspike intervals, i.e. the mean, the variance and the cross-correlations of spike activity. Since neurons emit and receive spike trains which can be described by renewalbut generally non-Poisson- processes, we first derive suitable diffusion-type approximation of such processes. Two novel approximation schemes are introduced: the usual approximation scheme (UAS) and the Ornstein-Uhlenbeck scheme (OUS). It is found that both schemes approximate well the input-output characteristics of spiking models such as the IF and the Hodgkin-Huxley model. The MNN framework is then developed according to the UAS scheme, and its predictions are tested on a few examples.

neuronal excitation and inhibition. This theory of epileptogenesis has been challenged by the finding that GABA does not always inhibit neuronal activity. Although in adult brain GABA usually induces hyperpolarization of cell membranes, in juvenile brain GABA is depolarizing, bringing the neuronal membrane closer to firing threshold, often enabling action potentials to be triggered. Somewhat surprisingly, GABA-mediated synaptic responses in adult brain tissue can sometimes be excitatory, too. Cohen et al. (2002) discovered a subpopulation of excitatory projection cells that exhibited depolarizing GABA responses in slices from epileptic adult subiculum. While most subicular pyramidal cells displayed hyperpolarized behavior in response to GABA, some actually fired bursts of action potentials, in synchrony with the interneurons; the GABA released by the interneurons was only depolarizing for this subset of excitatory cells. These results suggest that it is the interaction between excitatory projection cells depolarized by GABA and interneurons that initiates epileptiform events, at least in subiculum. Interneurons usually seem to provide an inhibitory shield around excitatory neurons. However, when connected to projection cells responding ëabnormallyí to GABA with depolarization, they may promote paroxysmal synchronizations. A summary of some recent theories and results is presented on possible causes and effects of depolarizing, GABA-mediated synaptic responses in the cerebrum. Special attention is focused on the hippocampal/parahippocampal formation, especially the subicular complex. The subiculum seems to be of particular interest because of its strategic output location to neocortex, and because of the spontaneous, interictal-like activity observed almost exclusively there in slices from patients suffering mesial temporal lobe epilepsy. Simulation results follow, starting from a commonly known GENESIS computer model of a small part of CA3. This ëCA3í was re-modeled to more closely resemble a small, ësubiculum-likeí structure, with a complement of fast-spiking interneurons and three types of projection cells: estrong-burstingí, eweak-burstingí, and eregular-spikingí. Parametric studies of the effects of increasing EGABA-A, the GABA reversal potential of certain GABA-A receptors, simulate the sometimes excitatory impact of GABAergic signaling. The effects of GABA-B receptor impairment in this setting are also briefly considered. Results presented here reinforce experimental evidence that the subiculum has ithe right stuffi to play a significant role in epileptiform events.

Synaptic transmission controlled by the release of the inhibitory

neurotransmitter GABA is generally considered to be the mechanism by which

glutamate-mediated excitation is kept under control in the human hippocampus and neocortex. Until recently, epilepsy was thought of as a simple imbalance of

#### Switching from integrators to resonators

Uwe Roehner, Jan Benda

ITB HU-Berlin, Berlin, Germany u.roehner@biologie.hu-berlin.de, j.benda@biologie.hu-berlin.de

They are two types of neurons, known as integrators and resonators. They are distinguished by the bifurcation type they undergo when excited. Integrators show a Saddle-node bifurcation while resonators a Hopf bifurcation, resulting in a negative or positive derivative of the steady-state Current(I)-voltage(V)-curve dI/dV, respectively. We investigate general conductance-based neuron models. For each

parameter we determine its possible influence on the transition from integrators to resonators, by looking at the derivative dI/dV. Our results show that the capacities C and the time constants tau have no influence. When considering passive currents we find that only their conductance g has an influence, while their reversal potential E does not. For currents equipped with gating variables we show analytically under which conditions g and E have an influence. We treat the parameters within the gating variables numerically and show that the midpoint potential  $V_{1/2}$  has an essential influence. To be more exactly, for two gating variables within one current we show that the overlap of both is crucial for the transition from integrators to resonators or vice versa.

Balanced input to the memory and background neurons during memory retrieval in an associative network

Yasser Roudi	Sunday PM Oral
Peter Latham	

Gatsby Computational Neuroscience Unit, UCL, London, UK

yasser@gatsby.ucl.ac.uk pel@gatsby.ucl.ac.uk

Neurons in the living brain fire in a highly irregular manner, as opposed to their response to a constant input in an in vitro preparation. However, there is no consensus as to what constitutes the source of this irregularity. Theoretical and experimental work shows that one candidate is a dynamically induced balance between excitation and inhibition. It has been shown previously that it is possible to reach a stable balanced state in a large neuronal network with "random" connectivity, provided that each individual synapse is strong enough. Here strong means that the synaptic weight, J, scales as  $(1/K)^{(1/2)}$ , where K is the average number of synapses per neuron. However, it is not clear how to achieve a balanced state in more realistic networks such as those that support associative memory (e.g. PFC, where highly irregular firing has been observed during delay activity). In fact, all models except one result in regular firing in the memory neurons . In the one model that did show irregular firing of memory neurons, the coding level, "a", which represents the fraction of neurons with elevated firing rate during memory retrieval, was much lower than experimentally observed values. Here we show that if the background strength of synapses scale as  $(1/K)^{(1/2)}$ , but the memory encoding part scales as (1/K) it is possible to achieve balanced memory states. To demonstrate this, we show that with this scaling the inhibitory and excitatory inputs to each neuron are both large (order  $K^{(1/2)}$ ), but the net mean input to all neurons is order one, as is the variance. This is in particular true for values of "a" consistent with experiment.

### Dynamics of Basal Ganglia-Thalamocortical Networks and Parkinsonian Tremor

Leonid Rubchinsky Monday Poster – M67 Karen Sigvardt

Dept Mathematical Sciences, IUPUI Stark Neurosci Res Inst, Indiana Univ Sch Med Indianapolis, Indiana, USA

leo@math.iupui.edu kasigvardt@ucdavis.edu

While it is well known that Parkinsonís disease (PD) results from the degeneration of neurons in the brain that contain the neuromodulator dopamine, we still lack understanding of how this loss of dopamine innervation results in the primary motor symptoms of PD, in particular, tremor (involuntary shaking movements of limbs). Even though much is known about the biophysics, anatomy and physiology of basal ganglia (BG) networks, the cellular and network basis of parkinsonian tremor remains an open question. A large body of experimental evidence supports the hypothesis, that the tremor arises due to pathological interaction of potentially oscillatory cells within the loop formed by basal ganglia and thalamocortical circuits. We suggest a model of this circuitry, which helps to clarify this mechanism of tremor genesis. The model consists of conductance-based units of pallidum (GP) and subthalamic nucleus (STN) connected in a simplified, but anatomically justified, network, mimicking basal ganglia ñ thalamocortical connections. We study how tremor arises due to the pathological properties of this loop, how it depends on the cellular and network parameters. This model illustrated the mechanism of ablative anti-parkinsonian surgeries, known to significantly diminish tremor in PD.

### How Much Can We Trust Neural Simulation Strategies?

Michelle Rudolph Alain Destexhe Sunday Poster - S72

UNIC, Gif-sur-Yvette, France rudolph@iaf.cnrs-gif.fr, alain.destexhe@iaf.cnrs-gif.fr

Computational neuroscience provides a growing number of tools which, together with the steady improvement of computational hardware, allow to simulate neural systems with increasing complexity ranging from detailed single cells to large scale neural networks. However, despite these advances, the results and, hence, qualitative interpretation of numerical simulations are still tightly bound to the simulation strategy used, and may vary across available simulation tools or for different settings within the same simulator. Specifically for networks of integrate-and-fire (IF) neurons, crucial differences in the occurrence of synchronous activity patterns were observed, depending on the temporal resolution of the neural simulator or the integration method used. Recently, a new event-driven simulation approach was proposed, which complements traditional clock-driven strategies. In contrast to the latter, where spiking and synaptic release events are bound to a temporal grid of finite resolution, eventbased methods keep the precise timing of events. Focusing on most commonly used clock-driven and event-driven approaches, in this contribution we evaluate to which extend the temporal precision of spiking events impacts on neuronal dynamics of single as well as small networks of IF neurons with plastic synapses. We found that the used strategy can severely alter simulated neural dynamics and, therefore, turn out to be crucial for the interpretation of the result of numerical simulations. Drastic differences were observed in models with spike timing dependent plasticity, arguing that the speed of neuronal simulations should not be the sole criteria for evaluation of the efficiency of simulation tools, but must complement an evaluation of their exactness, possibly in disfavour of their speed. Research supported by CNRS and EU (integrated project "FACETS", IST-15879).

#### Statistical similarity measures for stochastic firing data

Antti Saarinen Marja-Leena Linne, Olli Yli-Harja Sunday Poster - S59

Tampere University of Technology, Tampere, Finland antti.saarinen@cs.tut.fi, marja-leena.linne@tut.fi

When developing automatic parameter optimization methods for neuronal models it is imperative to be able to compare the output of the model with the learning data. This can be done, for example, by studying the norm of the difference between the model output data and the experimental learning data. The parameter values of the model are considered to be optimized when this norm is minimized. It has been shown, however, that this approach is not sufficient for models describing the electroresponsiveness of neurons. Cerebellar granule cell which is used as an example in our studies exhibits stochastic behavior and the responses to repeated current stimulation vary slightly. In model-level this means that we should get slightly different outputs with the same set of parameters. Therefore it is crucial to consider alternative ways of measuring similarity. In this work we use the mean firing rate, mean interspike interval, standard deviation of the interspike intervals, and the coefficient of variation to describe the characteristics of measured and simulated traces of firing data, and call the two traces similar if these measures match. First we take a look at the mean firing rate of a trace. This gives us the average firing frequency of the cell or the model. However, firing can be very irregular especially with small values of depolarizing current, and the length of interspike interval can vary. To capture this behavior we calculate also the standard deviation of the interspike intervals. Variability in the firing produced by the stochastic model used in this study can also be assessed by examining the histograms of interspike intervals. The histograms reveal that the stochasticity has major effect on the firing with current pulses near the threshold of firing. With larger depolarizing current pulses firing becomes more regular and the stochasticity does not have as clear an effect. This can be observed from the histograms as a smaller deviation in the interspike intervals. The coefficient of variation (CV) of the interspike intervals is also often employed to quantify the regularity/irregularity of action potential firing. A completely regular firing has a CV of zero. We conclude that using these similarity measures and the previously developed stochastic model, we are able to produce responses with matching statistical characteristics to real data. In the future, these kinds of similarity measures can be utilized when developing automated parameter estimation methods for stochastic neuron models.

#### Motor Planning and Sparse Motor Command Representation

Yutaka Sakaguchi, Shiro Ikeda Monday Poster – M84 University of Electro-Communications, Graduate School of Information Systems, Tokyo, Japan, <u>sakaguchi@is.uec.ac.jp</u>, shiro@ism.ac.jp

Information representation is a central problem in neuroscience. For the representation of visual inputs, Olshausen and Field (1995) proposed a computational model which explained the response properties of V1 simple cells. Compared to sensory input representation, the motor command representation has not been thoroughly discussed. In the present article, we propose a computational model for the motor representation, where each command pattern is realized as a linear combination of prefixed patterns, and discuss how it explains some features of our motor behavior. The idea to represent the motor command with linear combination of patterns is similar to the synergy decomposition model (d'Avella et al., 2003). However, our approach differs from it in two points. First point is the assessment of the motor command. The synergy decomposition model employs the approximation accuracy as the criterion, which is based on the dissociation between the observed EMG patterns and reconstructed motor command. Instead of this `optimal approximation criterion," we employ ``task optimization criterion" which is the task performance measure (e.g., endpoint error in reaching movement). This criterion is suitable for motor representation since the objective of motor system is to achieve the desired tasks. The second point is to introduce parameter preference into the motor command representation. In the feature extraction model by Olshausen and Field (1995), visual inputs are represented as the linear combination of features and the preference on sparse representation is assumed. The model was successful in reproducing the receptive field property of V1 neurons. We implemented similar idea to the motor representation model expecting it to explain human movement properties. The authors propose a novel two-termed criterion for motor planning, whose properties are summarized above. It consists of a task optimization term and a parameter preference term, and a motor command is generated by optimizing this criterion. In order to examine its validity, the authors ran a computer simulated experiment, taking a single-joint reaching task as an example. The result showed that movement time was determined dependent on movement distance and endpoint error, qualitatively consistent with Fitts' law. In summary, the authors propose a new approach of motor planning based on an "information representation criterion," instead of conventional "kinematics criteria". Our assumption of ``the parameter preference" corresponds to the assumption of signal dependent noise model (SDN) (Harris and Wolpert, 1998) in TOPS (task optimization with presence of SDN) model.

#### Simultaneous Determination of Depth and Motion in Early Vision

Ko Sakai, Mitsuharu Ogiya, Shiori Katsumata Monday Poster – M50 University of Tsukuba, Institute of Information Sciences, Tsukuba, Japan sakai@cs.tsukuba.ac.jp, mitsuharu@cvs.cs.tsukuba.ac.jp

We studied how the visual system determines simultaneously depth and motion of moving objects under ambiguous conditions. The inter-ocular time delay (ITD) that is temporal inconsistency between images projected onto the two eyes has been discussed widely because it appears to be a key for understanding the strategy of the visual system for the simultaneous determination of depth and motion. Our recent psychophysical study has shown that ITD alone evokes correct depth perception, suggesting that the visual system assumes a constant velocity and tries to estimate depth, indicating the precedence of depth perception over velocity. We first investigated psychophysically whether human observers are, in fact, incapable of determining correct velocity from ITD while they perceive correct depth. The stimuli consisted of stationary random dots with ITD positioned behind a thin slit. Subjects were asked to judge whether dots moved faster than a reference while the velocity of the reference was varied randomly. The apparent velocity was constant and independent of ITD, although the depth and motion direction were perceived correctly. The results suggest that the visual system assumes a constant velocity and interprets ITD as a depth cue, indicating the precedence of depth perception over velocity. Second, we investigated computationally the role of complex cells with the spatiotemporal response-characteristics in the simultaneous determination of depth and motion from ITD. Specifically, we carried out the simulations of a population of model complex-cells to examine whether the activities of the model cells with a variety of response profiles provide the basis for the perception of depth and motion from ITD. Each model cell realizes the binocular, spatiotemporal response characteristics by taking spatial pooling of appropriate simple subunits. Any cells tuned to a motion to left, regardless of velocity, are almost equally activated. This result suggests that complex cells do not determine a particular velocity from ITD, therefore the perception of velocity could be biased easily by any factor. This result is consistent with our psychophysical observation in that apparent velocity depends strongly on the velocity of a reference. Our results show that the precedence of depth perception over velocity in ambiguous conditions, and that a population of complex cells with spatiotemporal coding provides a basis for the simultaneous perception of depth and motion.

#### Subspace STC analysis using bias correction

Monday Poster - M54

#### Aman Saleem Simon Schultz

Imperial College London, London, U.K.

aman.saleem@imperial.ac.uk s.schultz@imperial.ac.uk

We propose a method to recover unbiased filters from a Spike Triggered Covariance (STC) on a subspace of white noise. If a neuron is described by a Linear Nonlinear Poisson (LNP) process, the STC is a very effective method in reconstructing a model of a neuron and has been used widely. But as the input in the analysis is white noise, the length of the recording varies as a square of the number of dimensions being explored, which makes the method impractical for studying a large number of dimensions. Exploring only a subspace would help reduce the time of carrying out the STC analysis and help increase the dimensions being studied. However, any deviation from white noise limits the effectiveness of STC and biases the recovered filters. We have been successful in getting an unbiased estimate of filters, by filtering out the covariance of the stimulus set from the covariance of the spike triggered ensemble, before carrying out the principle components analysis. We present examples that show its effectiveness on neurons simulated using different LNP models. The new method would greatly improve the efficiency of the STC analysis.

Exploring GABAergic and Dopaminergic effects in a minimal model of a medium spiny projection neuron

Ebba Samuelsson Jeanette Hellgren Kotaleski Monday Poster –M11

School of Computer Science and Communication, Stockholm, Sweden

ems@kth.se jeanette@csc.kth.se

Striatum is the input stage of the basal ganglia, a collection of nuclei in the midbrain. Basal ganglia are involved in cognitive and motor behaviour, including reward dependent learning. The reward system in the brain is heavily linked to the dopaminergic system, and many striatal neurons react in a reward dependent manner. This study explores a simplified model of a striatal medium spiny projecting (MS) neuron displaying dopamine-induced bistability. MS neurons mostly fluctuate between two states, a hyperpolarised down-state and a depolarised up-state. MS neurons are only active during the up-state and therefore spiking requires the transition from the down-state. GABAergic input to MS neurons results in a small depolarisation, far from causing a transition to the up-state by itself. We investigate, by using the simplified model, if an early GABAergic depolarisation can facilitate the glutamate induced transition to the up-state. The model predicts that GABAergic input to MS neurons from neighbouring interneurons might decrease the delay to and facilitate the up-state transition in the presence of dopamine.

### Mutual information and redundancy in cortical spike trains during the awake state

Maria V. Sanchez-Vives Janusz Szczepanski M. Marta Arnold Elek Wajnryb Sunday Poster –S22

mavi.sanchez@umh.es jszczepa@ippt.gov.pl

An important problem to understand neural processing is neuronal cooperation on information transmission. In the past we calculated the information carried in spike trains by estimating the normalized Lempel-Ziv complexity, which measures the generation rate of new patterns along a spike sequence [Szczepanski et al., 2003; Amigo et al., 2004] and we also estimated the extent to which the information carried by one neuron varies with different brain states [Arnold et al., 2005]. Here we have been interested in the relative information carried by neighboring neurons. What is the relation between the information carried by closely located neurons? How much redundancy is there? Do neurons function in an independent or synergic way? To answer these questions we analyzed two parameters that are important to characterize cooperation: mutual information and redundancy in spike trains from different neurons. We quantified both parameters for the spontaneous spike discharge of nearby cortical neurons. Electrical activity of neuronal clusters was recorded by means of chronically implanted tetrodes in the visual cortex of freely moving rats. Spike discharge was spontaneous, the recordings done in the dark and in the absence of visual stimulation. To analyze the information conveyed by a given neuron in relation to the one carried by a different neuron we introduce the concept of relative mutual information (RMI) [Borst, 1999]. RMI(X,Y) between information sources corresponding to a pair of neurons X and Y results from the comparison between mutual information I(X,Y) and average information transmitted by X and by Y. Redundancy(R) was estimated using the definition in [Reich et al., 2001]. R results from comparing the sum of information rates transmitted by neurons, each treated separately, with the information rate transmitted by the whole group. Evaluation of both R and RMI need an entropy estimator. To estimate the entropy rate at a given moment of time, we use normalized Lempel-Ziv complexity [Szczepanski et al., 2003; Amigo et al., 2004]. The results revealed an almost invariable RMI within all the different analyzed clusters of neurons. At variance from RMI, R was found to be very different for different neuronal clusters. Our results show that neurons can collaborate in a flexible way (both synergistically and with a leading neuron). The values of RMI obtained show that during information transmission, the mutual information between each pair of neurons remains at the same level in relation to the amount of information being transmitted by both neurons.

#### Scaling effects in a model of the olfactory bulb

Malin Sandström Jeanette Hellgren Kotaleski Anders Lansner Monday Poster – M79

Royal Institute of Technology, Dept. of Computer Science and Communication Stockholm, Sweden

 $ms and str@nada.kth.se\\jean ette@csc.kth.se$ 

Many computational models of the olfactory bulb are much smaller than any biological olfactory bulb ñ usually because the number of granule cells is much lower. The resulting distortion of the inhibitory input may distort network dynamics and processing. We have constructed a full-scale model of the zebrafish olfactory bulb, as well as three smaller models, using the efficient parallellizing neural simulator SPLIT and data from a previously existing GENESIS model. We are studying several characteristics - among them overall behaviour, degree of synchronicity of mitral cells and the time-scale of appearance of synchronicity ñ using cross-correlation plots and synthesized EEG:s. Larger models with higher proportions of granule cells to mitral cells (with the same amout of synaptic input) appear to give more synchronized output, especially for stimuli with shorter time-scales. Further expansion of the work, towards a complete olfactory system (olfactory receptor neurons, olfactory bulb and olfactory cortex) is in progress.

### Modelling the spinal cord and behaviour of the frog tadpole

Bart Sautois Steve Soffe Wen-Chang Li Alan Roberts

The hatchling Xenopus tadpole is capable of exhibiting two kinds of motion. When touched, it swims away, and while held itstruggles. The swimming behaviour has been studied thoroughly at the neuronal level in biological experiments. These indicate that the spinal cord network only consists of a couple of thousand neurons, which can be subdivided into as few as 10 types. Using an improved patch clamp method, we were able to make detailed measurements of individual neurons. We have built specific models for each type of spinal neuron, with distinct properties in spiking behaviour, threshold, spike width, etc. Using these individual models and biological data on their connections, we have built a model of the spinal network. This matches the physiological network model was able to reproduce the swimming response to a brief stimulus to one side, as in biology. Several important features of the physiological network can be found in our model network.

#### Perceptual learning by modifying top-down connections to V1

Roland Schäfer Eleni Vasilaki Walter Senn Sunday Poster –S3

Monday Poster – M65

Institute of Physiology, University of Bern, Bern, Switzerland

schaefer@cns.unibe.ch vasilaki@cns.unibe.ch

The primary visual cortex (V1) is known to extract basic geometric features such as position and orientation of edges (bars). Collinear edge detectors in V1 mutually enhance their activity in a nonlinear way, thereby allowing to highlight lines [1]. However, this basic wiring may be disadvantageous when subjects need to judge whether a segment within a line is brighter than a reference bar which is not part of the line, as required in the classical brightness discrimination task [2,3]. Global attention, suggested to enhance the neuronal gain in V1 [4], would additionally favor collinear edge detectors if it were unspecifically increasing the gain of the intrinsic V1 circuitries. On the other hand, task-specific attention and perceptual learning in brightness discrimination seem to undo the deteriorating effect of the collinear edge enhancement, without affecting the intrinsic wiring in V1. How is it possible that perceptual learning, typically ascribed to synaptic modifications in sensory areas, can improve the discrimination capability without touching the synaptic organization within V1 [2,3]? We suggest a model of top-down interactions in V1 according to which attention selectively increases the gain of pyramidal neurons while simultaneously driving inhibitory populations in V1. The task-specific gain increase enhances the stimulus sensitivity of V1 pyramidal neurons, and the activation of inhibitory neurons suppresses the intrinsic V1 circuitry favoring collinear edges. Our model quantitatively reproduces the performance increase in humans and monkeys during ongoing brightness discrimination training [2]. It simultaneously reproduces the response modulations of V1 neurons by collinear line segments with and without focal attention [3]. Perceptual learning in our model is explained by a Hebbian strengthening of top-down projections to V1 which both enhance the gain and suppresse intrinsic interactions in V1. In this interpretation, perceptual learning appears to be mediated by top-down rather than feed-forward synaptic modifications as commonly assumed. Learning through top-down modulation has the advantage of leaving the intrinsic V1 circuitry intact for the basic operations attributed to V1. [1] Kapadia et al., Neuron (1995) 15:843-56. [2] Ito et al., Neuron (1998) 20:1191-97. [3] Ito et al., Neuron (1999) 22:593-604. [4] Hillyard et al., Philos. Trans. R. Soc. Lond. B (1998) 353: 1257-1270.

Scaling properties of pyramidal neurons i	n mouse somatosensory cortex	Which spike train properties shape cross correlogra	ams?
Andreas Schierwagen Alán Alpár	Sunday Poster –S32	Gaby Schneider	Sunday Poster –S12
Ulrich Gärtner		University of Frankfurt, Dept. of Computer Science an Frankfurt am Main, Deutschland	d Mathematics
University of Leipzig, Leipzig, Germany		gaby.schneider@math.uni-frankfurt.de	
schierwa@informatik.uni-leipzig.de alpar@server3.medizin.uni-leipzig.de Dendritic morphology is the structural correlate for receiving and processing inputs to a neuron. In evolution and development, the size of neurons with their dendrites is changed. An interesting question then is what the design principles and the functional consequences of enlarged or shrinked dendritic trees might be. In this study, morphological data from transgenic mice pyramidal neurons has been used to investigate this problem. From previous analyses it is known that the volume of cerebral cortex in p21H-RasVal12 transgenic mice is increased by about 20%, if compared with the wildtype. This is caused by the fact that neurons in layer II/III show a significant growth and establish a more complex dendritic tree. We used compartmental modeling to explore the design principles and functional consequences of the enlarged transgenic mice pyramids. Two sets of pyramidal neurons from layer II/III (28 wildtype and 26 transgenic neurons) were reconstructed and digitized using NeurolucidaTM. The NEURON simulator has been employed to calculate the morphoelectrotonic transform (MET) of each neuron at different frequecies and for somatopetal and somatofugal inputs, respectively. The statistical analysis of the sample METs revealed global conformity between the two neuron sets, i.e. the electrotonic architecture of the transgenic neurons scales in such a way that signal propagation in the neuron models is scarcely affected.		Cross-correlation histograms (CCHs) are widely used to study the temporal interaction between pairs of spike trains. In particular, important features of oscillatory CCHs, such as the height and width of the central peak, the oscillation frequency or the number of visible side peaks, have been investigated in order to draw conclusions about properties of the underlying processes. We focus here on a special kind of asymmetry of the central peak, which concerns side differences in the width and the slope of the peak as well as in the depth of the side valleys. A model for the coordinated oscillatory firing activity of multiple neurons is presented, which provides an explanation for the observed aspects of asymmetry. In the doubly stochastic model, a stationary, periodic packet onset process (POP) gives rise to independent Poissonian spike packets with exponentially decaying firing rate. The units may differ in the decay but are assumed to share the same POP. With the presented model, many different CCH features can be quantified and related to spike train properties. A small set of parameters can produce a high variety of CCH shapes. In particular, one single parameter accounts simultaneously for all aspects of asymmetry. In addition to explaining important relations between different shape parameters of oscillatory CCHs, the model also suggests a precise relation between a CCH and the auto correlation histograms of the individual spike trains, which depend on the same set of parameters. Thus, a framework is provided that can be used to study particular aspects of pairwise interactions in multiple parallel oscillatory processes.	
Spatiotemporal Organization of Cortical I Steven Schiff Xiaoying Huang Jian-Young Wu George Mason University, Fairfax, Virginia,	Tuesday Poster –T29	A Computational Account of the Negative Priming Hecke Schrobsdorff Matthias Ihrke, Bjoern Kabisch, Joerg Behrendt Marcus Hasselhorn, Michael Herrmann	Effect Sunday Poster –S1
sschiff@gmu.edu xh4@georgetown.edu		BCCN Goettingen, G.A. University Goettingen, Goetti hecke@chaos.gwdg.de, ihrke@chaos.gwdg.de	ngen, Germany
Neural systems think through patterns of act formation in nonlinear systems driven far fro open problem today. I will show experiment of spontaneously organizing episodes of acti middle layers of rat visual cortex within whi organizing out of irregular and chaotic wave 9902, 2004). The spirals have true drifting p replicated in mean field continuum models of turbulence is striking, and we have explored experimental fluid dynamics to better unders applied a proper orthogonal decomposition, coherent structures that compose such activi illustrates the statistically most likely basis u dynamics. Indeed, one can often identify in o overwhelming amount of energy expressed i confined region of phase space. In the analys we find that the energy tends to concentrate coherent modes as these episodes organize, a number of modes prior to termination. Epile organizing oscillatory events, which have ree through a consistent set of dynamical stages Using the same principal orthogonal decomp	om equilibrium remains a largely s building upon the recent discovery vity from isotropic 2D slices of ch arise plane and spiral waves, activity (J. Neurosci. 24: 9897- hase singularities, behavior f cortex. The analogy with fluid techniques drawn from tand these phenomena. We have which illustrates the evolution of the ties. Such a decomposition pon which to project such complex systems that the n this basis takes place within a sis of these cortical wave dynamics, into a small number of dominant und then disseminates onto a larger ptic seizures also are spontaneously cently been shown to evolve (Neuroimage 28: 1043-1055, 2005).	In order to allow the human to perform reasonable actions possess effective and reliable mechanisms for flexibly stimuli. While low-level attentional mechanisms are redown to a neuronal level of description, the high-level be conceptually more difficult. However, the relevance evaluated ultimately only in the higher areas of the brain one of the major techniques to investigate the dynamic memory. In the experiments that are of relevance subjet between a target stimulus and a distractor. If the target changes place with the distractor in iterated trials, the vary systematically. In the latter case, in particular, whincrease as compared to unrelated stimuli across trials, as negative priming. Negative priming is a natural const for discrimination of relevant and irrelevant informatic as a suggestive probe for the flexible suppression of ir Unfortunately, the negative priming effects are prone to variability both inter- and intra-individually. This sens of the environment bears, however, also a potential to shypotheses on the underlying processes and resources. experiments on negative priming, we implement the Im model (ISAM) [1] that assumes an adaptive threshold a mechanism. Both the positive and the negative priming described by our computational formulation of the model we computational formulation of the mositive priming we implement the suppression of the model of the positive and the negative priming described by our computational formulation of the model we computational	ignoring irrelevant latively well understood counterpart has shown to e of a stimulus can be in. Priming effects are al organization of sets have to discriminate stimulus re-occurs or reaction time turns out to here reaction times tend to the effect is referred to sequence of mechanisms on and thus it may serve relevant information. o a considerable itivity to distracting parts specify and to test Based on results of our mago-Sensory-Action as a unique underlying g effect are quantitatively

Using the same principal orthogonal decomposition, we will further show evidence that the spatiotemporal coherent modes of such seizures may follow a similar organizing pattern as seen in the rat brain slice experiments. described by our computational formulation of the model, giving further justification of this approach. To test the implementation we discuss the dependency of the negative priming effect on the response-stimulus interval. We will first describe the paradigm to which we refer and shortly review the results of our recent psychological experiments regarding the negative priming

effect. The implementation is discussed in detail. Implications as well as limitations of the model in the implemented form are given. Finally we will integrate the ISAM in the existing models for negative priming. [1] B. Kabisch (2003) Negatives Priming und Schizophrenie - Formulierung und empirische Untersuchung eines neuen theoretischen Ansatzes. PhD thesis (Dissertation),

Friedrich-Schiller-Universitat Jena, Germany.

#### A Feature-Binding Model with Localized Excitations

 Hecke Schrobsdorff
 Sunday Poster -S28

 Michael Herrmann, Theo Geisel
 Sunday Poster -S28

BCCN Goettingen, G.A. University Goettingen, Goettingen, Germany <u>hecke@chaos.gwdg.de</u>, michael@chaos.gwdg.de

Information from different sources must be combined in order to perceive an object of multiple senses. Because the processing of the features of the object is performed each time independently the object is represented comprehensively only by the representation of interactions among the features. While single features may be be assumed to be represented by localized activity in a specialized brain area, the representation of the combination of several features requires a different mechanism. If synchronizations in the time domain are considered as a putative mechanism, it remains unclear how such coincident activities might come about, how they are hierarchically composed or how a component which is temporarily missing due to noise is resynchronized. Further the activation of a featural component should be preserved for short time intervals even if any matching features are absent. Among the other approaches to feature binding we merely mention the dynamic link matching algorithm and its predecessors [1], because there is some formal similarity to the present model. However, instead of postulating quickly rewirable synapse we put forward the idea that any two features are reciprocally connected though not directly but via a link neuron which is more frontal than either of the two. The fact that a link neuron has been engaged by a feature neuron is represented by a synchronized activity. We do not require a particular link neuron, instead we allow for a multitude of competing link neurons in order to cope with the combinatorial complexity of the matching problem. Encoding features by localized activity in networks of pulse-coupled neurons is present in spatially localized clusters of neurons that fire synchronously and periodically, thus preserving information. These localized excitations show a fast temporally periodic structure. We consider a chain of leaky integrate-and-fire neurons which are exchanging activation via delta spikes. The present feature-binding model uses localized excitations for communication between prefrontal cortex and feature-detecting brain regions. Three brain areas are simulated as chains of integrate-and-fire neurons at a parameter range where localized activity is possible. These different areas are coupled in an excitatory way, such that excitations of the different areas reentrantly activate each other. If they are thus dependent on each other they form at least temporarily a unit, representing a particular object in the model. [1] W. K. Konen , T. Maurer , C. v. d. Malsburg : A fast dynamic link matching algorithm for invariant pattern recognition, Neural Networks,(1994), pp.1019-1030.

#### Neural Control of Reactive Behaviors for Undulatory Robots

Michael Sfakiotakis Dimitris Tsakiris Sunday Poster - S56

Computational Vision and Robotics Laboratory Institute of Computer Science, FORTH, Heraklion, Greece

sfakios@ics.forth.gr tsakiris@ics.forth.gr

Undulatory locomotion is studied as a biological paradigm of versatile body morphology and effective motion control, adaptable to a large variety of unstructured and tortuous environmental conditions (e.g. the polychaete annelid worms move equally efficiently in water, sand, mud and sediment). Computational models of this type of locomotion have been developed, based on the Lagrangian dynamics of the system and on resistive models of its interaction with the environment, and have been validated on a series of lightweight robotic prototypes, whose undulatory actuation achieves propulsion on sand. The work described here extends these models of locomotion and motion control in two directions: one is the generation of sensor-based reactive behaviors, based on appropriate sensory information, and the second is motion control via biomimetic neuromuscular control, based on central pattern generators. This leads to reactive neuromuscular control schemes, which are used to generate the behaviors necessary to traverse corridor-like environments and maintain the cohesion of swarms of undulatory robots. Simulation studies demonstrate the possibility to generate undulatory reactive behaviors for such systems based on information from distance sensors. The expansion of our undulatory prototypes with an appropriate sensory apparatus, in order to validate such reactive control schemes, is in progress.

#### Favorable Recording Criteria for Spike Sorting

Sunday Poster -S14

Mona Sheikh, Don Johnson ECE department, Rice University, Houston, Texas, USA <u>msheikh@rice.edu</u>, dhj@rice.edu

Spike sorting refers to the detection and classification of electric potentials (spikes) generated by neurons. Spikes from multiple neurons recorded simultaneously in a single electric recording need to be separated into individual neuron streams before neuroscientists can interpret the data. This paper views recorded spikes as forming a signal constellation and analyzes spike sorting as a problem in detection theory. We characterize the optimal spike amplitudes that minimize error. Neuroscientists can use this information as a real-time guide during experiments when deciding which situations yield the smallest possible spike sorting errors regardless of algorithm being used.

## Applications of the Poincar\'e mapping technique to analysis of spike adding

Andrey Shilnikov Tuesday Poster –T23 Paul Channell, Gennady Cymbalyuk Dept Mathematics and Statistics Georgia State University, Atlanta, Georgia, USA ashilnikov@gsu.edu, pchannell1@student.gsu.edu

Here we report and describe in detail a new route from tonic spiking into bursting in a model of a leech heart interneuron, which we will refer to as a spike adding route. During this transition, as a bifurcation parameter is monotonically changed a sequence of bifurcations occurs causing incremental change of the number of spikes in a burst. A family of Poincar\'e return mappings for the membrane potential is used to study this transition.

### A self-organizing motor-control neural network model inspired by the basal ganglia

Osamu Shouno Monday Poster –M61 Johane Takeuchi, Hiroshi Tsujino Honda Research Institute Japan Co., Ltd., Wako, Japan <u>shouno@jp.honda-ri.com</u>, johane.takeuchi@jp.honda-ri.com

The basal ganglia are involved in learning and execution of sequential movements. In this paper, we propose our ideas of a new motion-control model for learning and execution of motion sequences based on the basal ganglia, and then demonstrate a type of activity pattern that is required for the model, in numerical simulations. The expected abilities of the model are the selforganization of combinations of analog output elements, the selection of the combination, and learning of relevant input space for the selected combinations. The model is an artificial neural network composed of synaptically coupled spiking neurons. The model consists of three layers connected in series. The input selection layer that corresponds to the striatum of the basal ganglia, provides multiple representations of a current state by the convergence of inputs coding variety of sensory and motor information. The combination selection layer that corresponds to the pallidum and subthalamic nucleus, generates a variety of motor patterns, and selects the pattern to be executed. The output layer of analog output elements that corresponds to the brainstem, forms analog output patterns. Our key idea is that the subthalamo-pallidal network of the combination selection layer is responsible for generation of motor patterns. We hypothesize that motor patterns are represented as spatiotemporal patterns of the subthalamo-pallidal oscillatory activity, based on the findings that the subthalamo-pallidal network intrinsically generates low frequency burst activities. Another key idea is the role of feedback projection from the combination selection layer to the input selection layer. The feedback projection selects input space relevant to the selected motor pattern, and defines a state based on the selected motor pattern. The interaction between the input selection and combination selection layers through feedforward and feedback projections could realize adaptive learning and execution of sequential movements. To represent motor patterns as the spatiotemporal patterns of the subthalamopallidal oscillatory activity, at least two types of activity are required. One is a spatial localized bump of activity pattern that corresponds to a motion to be executed. Another is traveling waves of activity pattern that can link localized bumps to form a temporal sequence of them. In our numerical simulations, we demonstrate that the former type of activity pattern is generated in a subthalamopallidal network with the off-center architecture of GABA-B lateral connections in the pallidum.

Spike frequency adaptation vs. synaptic depression slow processes in neural competition models	Investigating the properties of adaptation in a computational model of the olfactory sensory neuron	
Asya Shpiro Monday Poster – M57 Ruben Moreno-Bote	Fabio Simoes de Souza     Monday Poster – M76       Gabriela Antunes	
Nava Rubin John Rinzel	Research Imaging Center, UTHSCSA, San Antonio, Texas, USA	
Center for Neural Science, New York University, New York, New York, USA	desouzaf@uthscsa.edu gabrian@usp.br	
avs203@nyu.edu rmoreno@cns.nyu.edu We consider two different firing rate models to describe bistable alternation dynamics during binocular rivalry. In one model, it is spike frequency adaptation that underlies alternating dominance of two populations, in the other, it is synaptic depression. We describe the dependence of the rate (and existence) of oscillations on the strength of the input, assumed to be identical for each population. We ask whether these models satisfy Levelt's Proposition I (LP-I, 1968), which states that dominance durations decrease with increasing stimulus	We developed a detailed computational model of an olfactory sensory neuron to investigate the functional properties of the sensorial adaptation in the peripheral olfactory system. The model consists in a system of first-order differential equations that describes the time course of the different components considered, including the biochemical pathways in the cilia and the electrical compartments that represent the cilia, the dendrite, dendritic knob, the cell body and the initial segment of the axon. We used different protocols of stimulation to investigate the response of the model to constant or transient stimuli. In this way, it was possible to explore the occurrence of two types of adaptation mediated by	
strength (eg, contrast). We find that both mechanisms (adaptation and synaptic depression) produce behavior that conflicts with experimental results. Namely, a branch on the period vs. stimulus strength dependence appears that shows counter-Levelt-I behavior. Nevertheless, in the absence of input noise, these two models can be distinguished. With synaptic depression, the counter-Levelt branch is much more restricted, in terms of the range of input strength, than Levelt-like branch. With spike frequency adaptation, the ranges of the two branches are of the same order. In contrast, with noise present the dependence of dominance duration on stimulus strength is qualitatively similar for the two models; neither shows an asymmetry for LP-I and counter-LP-I range. Even in	distinct processes in the same cell. The results of the model suggest that apart from the nature of the stimulus that each part of the receptor cell reacts ñchemical or electric-, the combination of different mechanisms of adaptation in the olfactory sensory neurons is important to guarantee that the sensorial information will be transmitted to the central nervous system efficiently and without distortion.	
the absence of a slow process, when noise alone is generating alternations, the counter-Levelt behavior remains as significant as the Levelt-like one. Different criteria based on the statistical properties of the alternations are necessary in order to distinguish between various oscillation-producing mechanisms in neural competition models.	A Computational Model of the Signals in Optical Imaging with Voltage- Sensitive Dyes Yiu Fai Sit Monday Poster –M103 Risto Miikkulainen	
Modeling stress-induced adaptations in Ca++ dynamics	Department of Computer Sciences The University of Texas at Austin, Austin, Texas, USA	
Kyriaki Sidiropoulou <i>Monday AM Oral</i> Marian Joels Panayiota Poirazi	yfsit@cs.utexas.edu risto@cs.utexas.edu	
IMBB-FORTH, Vassilika Vouton, Greece	Optical imaging with voltage-sensitive dyes (VSD imaging) can record neural activity over an area of several square centimeters with high spatiotemporal resolution. The relative contributions of subthreshold and suprathreshold activity	
sidirop@imbb.forth.gr joels@science.uva.nl A hippocampal stress response is mediated by the glucocorticoid and mineralocorticoid receptors and involves primarily delayed changes in	to the VSD signal are, however, poorly understood, making it difficult to interpret the imaging result. This summary shows how the activity in a computational model of V1 can be related to the VSD signal. The orientation tuning curve and the response time course in the model match those observed in V1 with VSD imaging, suggesting that the model represents VSD signal	
hippocampal neuronal properties. In this study, we concentrate on stress-induced effects in CA1 neurons which include an enhancement of the slow afterhypolarization (sAHP), an increase in Ca++ currents, specifically an upregulation of the Cav1.2 subunit that mediates one type of the L-type Ca++	accurately and can be used to link neural activity to it. Toward direct links between model networks and experimental data	
current (the Ls type), and a suppression of Ca++ extrusion mechanism, manifested as a decrease in plasma membrane Ca++-ATPase-1. The aim of our	Frances Skinner Tuesday Poster –T43	
study lies in identifying a causal relationship between either or both of the changes in the Ca++ dynamics system and the increase in the sAHP. We used a	Toronto Western Research Institute	
theoretical CA1 neuron model that included detailed structural properties and biophysical mechanisms that was implemented on the NEURON simulation environment. Our compartmental CA1 neuron included modeling equations for	University Health Network, Toronto, Canada	
16 types of ionic mechanisms, known to be present in these cells. Among these, both types of L-type Ca++ current, one with normal activation kinetics (Ls) and	fskinner@uhnres.utoronto.ca Theoretical analyses of model networks and insights derived from model	
one with additional prolonged openings (Lp), Ca++-activated K+ conductances that underlie the AHP, and an integrated modeling equation for intracellular Ca++ decay comprising all Ca++ extrusion and buffering mechanisms were included. We found that the enhancement of sAHP could be explained not by an increase in Ls Ca++ current, bur rather by a decrease in the rate of intracellular Ca++ decay. Previous modeling work from our lab suggested that there might be a causal effect between an increase in the Lp Ca++ current and the aging- induced enhancement of the sAHP. However, a respective causal relationship between an increase in the Ls Ca++ current and sAHP enhancement does not seem to exist. Experimental and computational evidence imply that aging an	networks imulations need to be directly linked to experimental data of biological networks. This is a difficult task for several reasons including the level of model detail, the technical aspects of experimental recordings and different experimental contexts. We need to be able to quantitatively compare model and experiment network characteristics in addition to their output. A recently developed method called VmD allows one to estimate synaptic background activities from intracellular recordings. We use a VmD-based protocol on model inhibitory networks (in which the underlying dynamics are understood) to obtain synaptic distributions. We show that the obtained distributions reflect the known model network characteristics and change appropriately with parameter changes.	
stress induce different Ca++-dependent cellular adaptations in CA1 neurons which, however, result in a similar phenotype of enhanced sAHP and subsequent decreased neuronal excitability.	This suggests that such a VmD-based protocol could be used to directly link model networks and experimental data.	

Testing spike detection and sorting algorithms using synthesized noisy spike	An
	dev

Leslie Smith	Sunday Poster – S52
University of Stirling, Stirling, UK	
lss@cs.stir.ac.uk	

Neural signals recorded by extracellular electrodes (particularly signals from multi-electrode arrays at the bottom of culture dishes) often suffer from low signal: noise ratios making spike detection and sorting difficult. Assessing the quality of existing algorithms for detecting and sorting spikes is difficult because one does not know when the spikes occurred. We have developed a noisy spike generator which generates signals for which the iground truthî is known. This is based on an equivalent circuit for the transfer of charge from neurons to an electrode. We simulate three sets of spiking neurons: target neurons, namely those for which we hope to detect and sort spikes, correlated noisy neurons, namely neurons which generate spikes which are correlated with one of the target neurons, and uncorrelated noisy neurons which generate spike trains uncorrelated with the target neurons. We emulate variations in the spike train shape and size (as recorded at a single electrode) caused by (i) variations in the distance of the different parts of the spiking surface from the neuron, (ii) variations in the mode of transfer of the signal to the electrode, and (iii) shape of intracellular spike. The circuit model provides justification for techniques for computing the effect of the spatiotemporal distribution of the spike on the spiking area of the neuron membrane as a weighted sum of delayed spikes, (permitting variation in electrode/neuron distance within a single neuron to be modelled), and computing the effect of the transfer path as a weighted sum of the intracellular spike and its first and second derivatives. In both cases, the weights are user specified, permitting considerable variation of the recorded spike shape and user determination of the relative strengths of the different components. The user can alter the shapes of the target neural signals, and the relative strengths of all the different signals. For an appropriate parameter selection, the signal generated looks like a real electrode signal. Spike times for all target neurons are recorded (and may be re-used), so that the results from different spike detection and sorting algorithms may be compared with the ground truth. The experimenter may vary the strengths of the signals and the noise. The software is a set of MATLAB .m files (requires Statistics Toolbox), (version 0.3) and is freely available from

http://www.cs.stir.ac.uk/~lss/noisyspikes. It consists of a set of .m files, and a user manual.

## Analytical Derivation of Complex Cell Properties from the Slowness Principle

Henning Sprekeler, Laurenz Wiskott Monday Poster – M51 Humboldt-Universitat Berlin, Institute for Theoretical Biology, Berlin, Germany h.sprekeler@biologie.hu-berlin.de, l.wiskott@biologie.hu-berlin.de

Ever since the seminal experiments by Hubel and Wiesel (Journal of Physiology, 1968), cells in V1 are usually conceived as edge detectors. These cells are commonly categorized as simple and complex cells based on their degree of invariance with respect to phase shift of their preferred stimulus. Further physiological studies revealed additional receptive field properties such as orientation and frequency selectivity (De Valois et al, Vision Research, 1982; De Valois et al, Vision Research, 1982). Recently, Berkes and Wiskott (Journal of Vision, 2005) demonstrated that the unsupervised learning principle of temporal slowness can account for a wide range of complex cell properties, including optimal stimuli, phase shift invariance, and orientation and frequency selectivity. Their simulations showed that the properties of the simulated receptive fields crucially depend on the transformations present in the image sequences used for training while being largely independent of the statistics of natural images. We will present a mathematical framework for their simulations, which is based on the Lie group of the transformations used in the simulations. It allows to analytically derive non-linear receptive fields whose properties are in agreement with the simulations and with physiological data. Apart from showing that the results of the simulations can be largely understood analytically, our theory provides an intuitive understanding of the selforganization mechanism in the principle of temporal slowness. The success of the theory confirms the conclusion of Berkes and Wiskott that the properties of the functions, which optimize temporal slowness are not adaptations to the content of the images used for training but to the transformations present in the training data. The agreement of the model with physiological data suggests that the structure of receptive fields in V1 may be the results of an adaptation to dominant transformations in natural visual scenes.

### Analysis of morphogen gradient interpretation mechanisms in the developing brain

Shyam Srinivasan Edwin Monuki Wayne Hayes

Sunday Poster –S35

University of California, Irvine, Irvine, California, USA

shyams@uci.edu emonuki@uci.edu

Our primary goal is to investigate the mechanisms, which lead to the formation of distinct areas in the cortex. A crucial link in the sequence of events from embryogenesis to corticogenesis is the mechanism of morphogen interpretation at the cell level. In this study we focus on instances of morphogen interpretation, which lead to bistable behavior in the developing brain. Morphogens are secreted by various patterning centers in the brain, and their concentrations change in both space and time. These spatio-temporal changes influence cell specification, proliferation, and the activity of induced genes. Understanding morphogen gradient interpretation mechanisms at the cellular level is fundamental to understanding development. One result of the interpretation mechanism could be bistability, in which a system is capable of displaying two different states under similar conditions, depending upon how it got to that state---ie., based solely on its history. We identify several candidates of morphogen induced bistability in the developing brain based on a) morphogen and induced gene expressions, and b) cell interaction network structures. We analyse the dynamics using both discrete and continuous simulation. The dynamical behaviour of the continuous system is described in large part by ``circuits" in the Jacobian matrix of the the system of ordinary differential equations. The primary requirement for bistability is that the Jacobian has either two feedback circuits of opposing signs, or an ambiguous circuit. The positive circuits contribute to switching between the two steady states, while the negative circuits contribute to stability in a given state. Furthermore, any two positive circuits could differ fundamentally on the basis of the inter-element architecture, giving rise to distinct morphologies; either a bistable switch-like behavior, or adjacent regions expressing antagonist molecules, with a sharp boundary in between. As the cortex exhibits several of these morphologies, we investigate these cell interaction networks for features of bistability such as positive and negative feedback loops. In the process, we elucidate the sequence of interactions, and identify likely players, hitherto unknown, in the signalling sequence.

#### Self-organisation explains discontinuities in the somatosensory map

Tom Stafford Stuart Wilson

Sunday Poster –S36

Department of Psychology, University of Sheffield, Sheffield, UK

t.stafford@shef.ac.uk pca03spw@shef.ac.uk

The primary somatosensory cortex contains a topographic map of the body surface, with two notable discontinuities of the representation of the face is next to that of the hands, and that of the feet next to the genitals. Farah (1998) has suggested that these discontinuities are the result of the interaction of cortical self-organisation with prenatal co-activation of these areas (because in the womb they are touching, even though they are distal in terms of the body surface). We use a Kohonen self-organising map to provide an existence proof of the plausibility of Farahis hypotheses. We then use the model to test viability of other possible causes of the known map structure and to explore the limitations of self-organisation for explaining the features of the somatosensory map.

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#### Decoding modulation of the neuromuscular transform

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Estee Stern	Sunday Poster –S15	-	
Timothy Fort		Volker Steuber	Monday PM Or
Mark Miller		Jason Rothman	
Charles Peskin		Laurence Cathala	
Vladimir Brezina		R. Angus Silver	
Mount Sinai School of Medicine, New York, New Yo	rk USA	University College London, London, UK	
Mount Smar School of Medicine, New Tork, New To	IK, USA	University Conege London, London, OK	

estee.stern@mssm.edu, tfort@neurobio.upr.clu.edu

Neuromodulators regulate many neurophysiological processes. These processes are often modeled as input-output relationships. Here we consider the example of the neuromuscular transform, the transformation of the pattern of motor neuron spikes to the waveform of muscle contractions that the spikes elicit. If a modulator, to meet some physiological demand, must alter the output contractions in a particular way, how can it accomplish this? Experimentally, it is observed that it generally alters the input spike pattern. Yet both theory and experiment strongly suggest that this alone will often be insufficient. This is because the neuromuscular transform acts as a constraining channel whose properties are tuned, at any particular time, only to a narrow range of input patterns. When the input pattern is modulated outside this range, the output contractions will not be able to follow. To allow them to follow, the properties of the neuromuscular transform must be retuned correspondingly. Physiological modulators of neuromuscular function are thus predicted to act simultaneously both on the input spike pattern and on the input-output relationship, the neuromuscular transform. Here we confirm this prediction by analyzing data from the cardiac neuromuscular system of the blue crab Callinectes sapidus, modulated by crustacean cardioactive peptide. We apply a method that decodes the contraction response to the spike pattern in terms of three elementary building-block functions that completely characterize the neuromuscular transform, in the unmodulated and modulated system. This method allows us to dissociate the changes in the neuromuscular transform from the changes in the spike pattern in the normally operating, essentially unperturbed neuromuscular system.

#### Robust performance of inhomogeneous forgetful associative memory networks

David Sterratt	Sunday PM Oral
David Willshaw	

Institute of Adaptive & Neural Computation, University of Edinburgh Edinburgh, Scotland david.c.sterratt@ed.ac.uk, d.willshaw@anc.ed.ac.uk

We investigate how various inhomogeneities present in biological synapses and neurons affect the performance of the linear associative memory model, a high level model of hippocampal circuitry and plasticity. The inhomogeneities incorporated into the network model are: differential input attenuation, stochastic synaptic transmission and memories learnt with varying intensity. Experiments show that synapses in CA1 cells appear to be scaled so as to compensate for differential attention of proximal and distal inputs, suggesting that differential attenuation could severely disrupt the computation of the cell. We determine the memory capacity of the network with an arbitrary learning rule using a signal to noise ratio (SNR) analysis. The SNR in an inhomogeneous network is related to the SNR in an equivalent homogeneous network by a factor that depends on the coefficients of variation (CVs) of the attenuation factors, stochastic transmission factors, and the learning intensities of the memories. The effects of the different forms of inhomogeneity are independent of each other. For distributions of attenuation factors and and stochastic transmission factors typical of hippocampal CA1 cells and their Schaffer collateral inputs, we find that the SNR is reduced by a factor of 1.4 due to differential attenuation. This is lower than the reduction in SNR due to stochastic transmission of a factor of around 3.5. Thus differential attenuation does not seem to disrupt the network computation as much as the compensation exhibited in nature might lead us to expect. Nevertheless the effect of compensating for attenuation will not be diminished by other inhomogeneities, due to the independence of the types of inhomogeneity. We apply the general result for patterns learnt with different intensities to a learning rule that incorporates weight decay. This network has the palimpsest property of being able to store patterns continuously at the expense of older ones being forgotten. We show that there is an optimal rate of weight decay that maximises the capacity of the network, and that the capacity of the network is a factor of e lower than its non-palimpsest equivalent. This result has not been derived in the context of other inhomogeneities before.

#### Short-term depression amplifies gain modulation by tonic inhibition in robollar granulo colle

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v.steuber@ucl.ac.uk j.rothman@ucl.ac.uk

Multiplicative gain modulations change the slope of the input - output relationship of neurons and alter their sensitivity to changes in excitatory inputs. They are observed frequently in vivo and are thought to play an important role for the processing of information in the brain. A common feature of conditions where multiplicative modulation takes place is the presence of noise, either as background or in the driving inputs themselves. As the amount of noise depends on the amplitude of synaptic inputs, synaptic plasticity is expected to affect the extent of gain modulation. In the cerebellum, synapses between mossy fibres (MFs) and granule cells (GCs) undergo short-term depression (STD). We used computer simulations and electrophysiological recordings to study the effect of STD on gain modulation by tonic inhibition in GCs. We injected depressing and non-depressing conductance trains into GCs in cerebellar slices and found that short-term depression (STD) of synaptic inputs resulted in a large enhancement of gain modulation by a tonic inhibitory conductance. STD has two effects: it reduces the amount of noise in the inputs, and it introduces a non-linear relationship between input rate and mean input conductance. Using a simple STD model, we could show that the effect of the non-linearity dominated the noise effect for all levels of STD. Our results suggest that the presence of STD at the MF-GC cell synapse could optimise gain modulation at the cerebellar input stage.

#### The Effect of Background Noise on the Precision of Pulse Packet **Propagation in Feed-Forward Networks**

Marcel Stimberg Thomas Hoch Klaus Obermayer Monday Poster - M96

Berlin University of Technology, BCCN Berlin, Berlin, Germany

mst@cs.tu-berlin.de hoch@cs.tu-berlin.de

Synchronous activity is prevalent in the visual cortex, suggesting that the precise timing of spikes plays a functional role in information processing. At the same time, cortical neurones are subjected to a constant bombardment of synaptic input, the so called background noise. Our work focusses on the question whether precise spike timing can be conserved through several stages of a feedforward network despite this background noise. We modelled a fully-connected feed-forward network of Hodgkin-Huxley neurones with purely excitatory synapses. The background activity was simulated by fluctuating conductances, a model that has been shown to recreate several properties of real cortical neurones in the high-conductance state. The network implements a synfire chain: Waves of synchronous activity, described as pulse packets, propagate across the layers of the network and evolve into a stable state of activity. We then examined the reliability (i.e. the probability that a pulse packet is successfully propagated) and the precision (i.e. the trial-to-trial variability of the pulse time) of such waves of synchronous activity in the presence of background noise. We classified pulse packets as either suprathreshold or subthreshold. The boundary between the two regimes is determined by the background noise: Stronger noise (i.e. a higher average membrane potential and/or stronger fluctuations) makes otherwise subthreshold pulse packets become suprathreshold, the well known stochastic resonance effect. Suprathreshold pulse packets and pulse packets that are only slightly subthreshold both propagate very reliably. They evolve into the same stable pattern of activity, surprisingly independent of the background noise. However, the precision of the propagation is very different: Suprathreshold pulse packets are propagated with submillisecond precision whereas subthreshold pulse packets are propagated very imprecisely. In sum we conclude that a precise transmission of pulse times can be achieved by propagating suprathreshold pulse packets. Precise timing by propagating subthreshold pulse packets on the other hand seems very unlikely.

Modelling Spontaneous Recovery of Memory		Temporal order of synaptic filters	: implications for F->D or D->F processes
James Stone Peter Jupp	Sunday Poster – S96	Krisztina Szalisznyo Janos Toth	Tuesday Poster – T83
Psychology Dept, Sheffield, UK <u>j.v.stone@shef.ac.uk</u> , pej@st-andrews.ac.uk		RMKI, KFKI, HAS, Budapest, Hung	gary
After a language has been learned and then forgotten, relearning some words appears to facilitate spontaneous recovery of other words. More generally, relearning partially forgotten associations induces recovery of other associations in humans, an effect we call 'free-lunch learning' (FLL). Using neural network models, we prove that FLL is a necessary consequence of storing associations as distributed representations. Specifically, we prove that ({\em a}) FLL becomes increasingly likely as the number of synapses (connection weights) increases, suggesting that FLL contributes to memory in neurophysiological systems, and ({\em b}) the magnitude of FLL is greatest if inactive synapses are removed, suggesting a computational role for synaptic pruning in physiological systems. As FLL is a generic property of distributed representations, it may constitute an important factor in human memory. <b>Branching Dendrites with Resonant Membrane</b> Sunday Poster –S34		efficacy increase and decrease, and t short term synaptic plasticity forms a facilitation arising from presynaptic, processes (e.g. as a result of postsyn- in serially arranged synaptic filters, v important. Growing body of literatur types of these plasticities. The molec always separate, but the exact level of Often it is experimentally difficult to transmission, therefore the temporal describing these processes is arbitrar	while depression from postsynaptic aptic receptor desensitization). This results where the order of these filters is likely re suggests more complicated interaction cular machinery of these processes are not of their interdependence remains unclear. o measure the details of the plastic synaptic order of the phenomenological models rily chosen. We examined the possible
Carl-Magnus Svensson Yulia Timofeeva Stephen Coombes			lers of synaptic plasticities and point out in order to have exchangeable filters, even is
The University of Nottingham, Nottingham, UK pmxcms1@nottingham.ac.uk, yulia.timofeeva@no	ttingham.ac.uk		
Dendrites form the major components of neurons. structures that receive and process thousands of syn neurons. Studies such as [MS96] have shown that of important role in the function of dendrites. Another	haptic inputs from other lendritic morphology play an	Computational Mechanisms for Pl Conditioning David Tam	hysiological Adaptation and Reflex Monday Poster –M28
dendrites is resonant membranes [Koc84]. In our work we will combine the effects of the dendritic architecture and underlying membrane dynamics. This is done by generalising the ``Sum-Over-Paths" approach presented in [AGF91] to the case of quasi-active membrane. The simplest case is to look at passive dendrites but we are more interested of the quasi-active case. One aim of this work is to develop a biophysically realistic model of branched dendritic tissue with quasi-active membrane that is both computationally inexpensive and mathematically tractable. Experimental data from neuroinformatic databases is used in conjecture with our theoretical framework to shed light on the role of architecture and resonances in determining neuronal output.		University of North Texas, Denton, Texas, USA dtam@unt.edu Physiological adaptation is a process in which, given a stimulus, the response is increased (or decreased) by sensitization or desensitization. The adaptation can be used to modify physiological reflexes to enhance or diminish the responses. The computational mechanism for the establishment of the reflex action, and the adaptation process that leads to the alteration of reflex by conditioning is examined. The neural circuitry involved in this adaptation process is also explored. We will us a biological Hebbian associative learning rule with a	
Spread of activation along specific lateral pathw primary visual cortex	vays in microcircuits of the	reinforcer to simulate a goal-directed learning neural network in this invoke the stretch reflex in equilibrium balancing. It can be shown that stretch reflex circuitry can be modified and adapt to changes in balance	
Andrew Symes Monda Thomas Wennekers	ay Poster –M53	The Micro-Structure of Attention	Sunday Poster –S6
University of Plymouth, Plymouth, UK andrew.symes@plymouth.ac.uk, thomas.wenneker	s@plymouth.ac.uk	Neill Taylor, Matthew Hartley, John	
The spatiotemporal behaviour of neurons within th defined in terms of the properties of spatially local characteristics of which include orientation selectiv physiological evidence suggests that such neurons over a much more extensive spatiotemporal range, by more distant cells, but also earlier stimuli. In co anatomical data demonstrates that lateral connectiv can extend over considerable distances, and demon for similar orientation tunings. Using this connectiv constructed a simulation model representing a smal Preliminary results corroborate the physiological fi demonstrate that spatiotemporally discrete stimulat that are remote both in space and time. Activity is of specific lateral and local synaptic connections, and properties of excitatory and inhibitory pathways. F tuning of such cells is highly correlated with that or results suggest that lateral connectivity plays an im processing by the visual cortex, and that cells integ information than is present simply in localized rece	receptive fields, vity. Conversely, recent in fact integrate information with activity driven not only njunction with this, ity within the striate cortex strate significant preference vity architecture we have II patch of the visual cortex. ndings and clearly ion evokes activity in cells observed to spread along is shaped by the different urthermore the orientation f the stimulus site. These portant role in information rate considerably more	53) on the modification of the respon- to one of two stimuli in the receptive away condition. Various different for modulation of lower level cells migh- proposed as a possible modulation, i amplifies input weights to a cell aris possible to use output gain as a mod- multiplies the whole output of the ce- attention feedback mechanism, popu- component to the input to a given ce- Reynolds et al paradigm we examine similar to the experimental results in neurons with noise. For the three for	nth.kcl.ac.uk eynolds et al.1999, J Neurosci 19(5):1736- nse of neurons under endogenous attention e field of a given cell, or under the attend rms have been suggested that attention it take. Thus contrast gain has been n which the attention feedback signal ing from a given attended stimulus. It is also ulation, where the attention feedback ell being attended to. Finally another ilar among modellers is an additive 11. In a simulated task based on the e which form of attention produces results a system of leaky-integrate-and-fire ms of attention, only that applied as contrast rimental results for the calculated regression

Time scale dependence of neuronal correlations		EvOL-Neuron: method and prospects	Sunday Poster –S41
Tom Tetzlaff Stefan Rotter Ad Aertsen Markus Diesmann	Tuesday Poster –T18	Ben Torben-Nielsen Karl Tuyls Eric Postma	
BCCN Freiburg, Biology III, University Freiburg		IKAT, University Maastricht, Maastricht, The Netherl	ands
Freiburg, Germany		b.torben-nielsen@cs.unimaas.nl k.tuyls@cs.unimaas.nl	
tom.tetzlaff@biologie.uni-freiburg.de rotter@biologie.uni-freiburg.de		Virtual neurons are used in the neuroscience communi	ty to counter the lack of

Neural activity is measured and quantified at various signal levels (e.g. spike counts, synaptic currents, membrane potentials, LFP, EEG, fMRI BOLD). Correlation analysis at these different levels is used to investigate the interplay between different neurons or neuron populations. Recent studies have utilized correlation measures to discover how different signal types relate to each other, and to the spiking activity mediating the fundamental interaction of the elements constituting the system. It has also been argued that the neuronal dynamics itself depends on the spatial and temporal correlations of input signals at different levels (e.g. spikes, synaptic currents). In this study we focus on signals which are derived from spike data by linear filtering. We investigate how correlation measures such as the standard correlation function, the joint PSTH, or the correlation coefficient are altered by the filtering procedure and highlight the consequences for the measurement and interpretation of correlations on the one hand, and for neural dynamics on the other. By generalizing shot-noise theory to joint (non-stationary, non-Poissonian) point processes, we show that filtering of spike signals by some linear kernel is accompanied by linear filtering of their correlation functions. To illustrate the effects, we construct common-input models which simultaneously enable us to generate correlated spike processes in a simple but realistic manner and describe the resulting correlation functions analytically. Surprisingly, the deformation of spike train auto- and crosscorrelation functions by linear filtering generally leads to a dependence of the correlation coefficients on the properties of the filter kernel. In particular this holds for spike count signals, where correlations exhibit a clear bin-size dependence. We point out that in common-input systems, classical pairwise correlation measures are determined by the marginal second-order statistics of the presynaptic sources represented by their auto-correlations. We present methods which eliminate these auto-correlation effects for specific examples, thereby allowing an interpretation of measured correlations in terms of anatomical structure. Moreover, we demonstrate how features of the filter kernel can be reconstructed from auto- and cross-correlations of the filtered signals. In order to emphasize the relevance of our findings for biological systems, we consider a network model of a small cortical area with realistic anatomical and electrophysiological parameters. This example shows how global network oscillations as observed both experimentally and theoretically can effectively control the strength of correlations at different signal levels.

#### Branched dendritic tree with active spines

Yulia Timofeeva Stephen Coombes Gabriel Lord

University of Nottingham, Nottingham, UK

yulia.timofeeva@nottingham.ac.uk stephen.coombes@nottingham.ac.uk

The dendrites of many nerve cells are complex branching structures that receive and process thousands of synaptic inputs from other neurons. Dendritic spines can be present in large densities on the dendrites. They are equipped with excitable channels and loci for receiving excitatory synaptic input. Here we introduce a mathematical model of a branched dendritic tree based upon a generalisation of the analytically tractable Spike-Diffuse-Spike model. The active membrane dynamics of spines are modelled by an integrate-and-fire process. The spines are assumed to be discretely distributed along a passive branched dendritic structure. We obtain a quasi-analytical solution using the ësum-over-pathsi approach formulated by Abbott et.al. (Biol. Cybern., 1991, vol.66, pp. 49-60). The model supports saltatory travelling wave propagation and wave scattering amongst branched dendritic trees. It is ideally suited for the study of spatio-temporal filtering properties and neural responses to different patterns of synaptic input. Virtual neurons are used in the neuroscience community to counter the lack of vast amounts of biological morphometric data. These digital neurons can be used for extensive modelling. A great deal of virtual neurons is generated or reconstructed algorithmically. However, a main disadvantage is identified in the algorithmic methods: they impose potentially unreliable a priori constraints on candidate virtual neurons. We present an algorithmic method, EvOL-Neuron that overcomes this disadvantage by imposing a posteriori limitations. EvOL-Neuron is empirically validated and prospective lines of research are discussed.

#### Coherent response of the Hodgkin-Huxley neuron in the high-input regime

Alessandro Torcini Stefano Luccioli Thomas Kreuz Sunday Poster -S67

Istituto dei Sistemi Complessi, CNR, firenze, Italy

torcini@ino.it luccioli@inoa.it

The response of the Hodgkin-Huxley neuronal model subjected to a large number of stochastic inhibitory and excitatory post-synaptic spike trains is analyzed. The model is examined in its three fundamental dynamical regimes: silence, bistability and repetitive firing. Its response is characterized in terms of statistical indicators (interspike-interval distributions and their first moments) as well as of dynamical indicators (autocorrelation functions and conditional entropies). In the silent regime, the coexistence of two different coherence resonances is revealed: one occurs at quite low noise and is related to the stimulation of subthreshold oscillations around the rest state; the second one (at intermediate noise variance) is associated with the regularization of the sequence of spikes emitted by the neuron. Bistability in the low noise limit can be interpreted in terms of jumping processes across barriers activated by stochastic fluctuations. In the repetitive firing regime a maximization of incoherence is observed at finite noise variance. The role played by correlations among synaptic inputs in enhancing or depressing the coherence effects is also investigated.

Attractor Neural Networks with Activity-Dependent Synapses: The Role of Synaptic Facilitation

Joaquin Torres Jesus M. Cortes, J. Marro, Hilbert J. Kappen Sunday Poster -S104

Department of Electr. and Physics of Matter, Granada, Spain jtorres@onsager.ugr.es, jcortes@onsager.ugr.es

We studied the behaviour of an autoassociative neural network with dynamic synapses including a facilitating mechanism. We have developed a general mean-field framework in which one can study the relevance of the different parameters defining the dynamic of the synapses, and their influence on the collective properties of the network. Depending on these parameters, the network shows different types of behaviour including a retrieval phase, an oscillatory regime, and a non-retrieval phase. In the oscillatory phase, the network activity is continously jumping between the stored patterns. Compared with other activity-dependent mechanisms such as synaptic depression, synaptic facilitation enhances the network ability to switch among the stored patterns and, therefore, its adaptation to external stimuli. A detailed analysis of our system reflects an efficient --more rapid and with less errors-- network access to the stored information if one considers facilitating mechanisms. Finally, we present a set of Monte Carlo simulations confirming our analytical results.

Monday Poster -M37

Probabilistic, weight-dependent STDP leads to rate-dependent synaptic fixed points		Theta synchronization in the medial septum and the role of the recurrent connections		
	Thomas Trappenberg, Dominic Standage	Tuesday Poster – T80	Balzs Ujfalussy	Tuesday Poster –T19
			Mihly Hajs	
	Dalhousie University, Faculty of Computer Science,		Tams Kiss	
	Halifax, Nova Scotia, Canada		Peter Erdi	
	tt@cs.dal.ca, standage@cs.dal.ca			
			Department of Biophysics, KFKI, Budapes	st, Hungary
	Computational studies have explored the consequences	of plasticity on the		, , ,
	distribution of synaptic strengths, but most of this work	has not clearly	ubi@rmki.kfki.hu	
addressed correlated pre- and post-synaptic activity. An important issue for		mihalyhajos@pfizer.com		
	modelling plasticity is limiting synaptic strength follow	1		
	correlations among input spikes can drive synapses wit	6	Medial septum-diagonal band (MSDB) con	mplay is considered as approximator
			1 0 1	1 1
	recently proposed a new interpretation of Bi and Poo's	· / 1	for hippocampal theta rhythm. Identificatio	21 /
dependent plasticity (STDP) data, deriving a weight- and spike-time-dependent		electro-physiological properties and their possible function in the generation of a		
plasticity rule that leads to fixed points of synaptic weights following correlated		synchronized		
	pre- and post-synaptic spike trains. Under our rule, fixe	d points are achieved by	activity in the MSDB is a hot topic. A recent	nt

a balance of LTP and LTD, where LTD increases faster than LTP and therefore dominates strong synapses. These fixed points are dependent on the rate and distribution of pre-synaptic spikes, post-synaptic spike latency, and the probability of synaptic transmission. Here, we hypothesise that LTP is probabilistic, depending on the initial strength of synapses. This hypothesis is consistent with the data used to derive our rule, and is testable under established STDP protocols. We build on our previous work by adding a weight-dependent probabilistic term to our plasticity rule. Without this term, fixed points are several orders of magnitude larger than experimental values, and our rule leads to runaway weights when LTP is isolated from LTD, as is typically the case in STDP protocols. We show that our new, probabilistic rule retains the features of our earlier rule, but lowers fixed points to biologically realistic values. This rule leads to stable LTP in the absence of LTD, without recourse to a cap on synaptic strength. We further demonstrate that associations between presynaptic events driving a model neuron are captured by this rule, so that several synapses are on average required to drive the neuron following associative learning, commensurate with biological findings.

#### A neural network approach of the sheep milk-ejection reflex

Anastasia Tsingotjidou Tuesday Poster – T58 Lazaros Iliadis, Christos Batzios, Georgios C. Papadopoulos Lab. of Anat. and Histol., Fac. of Vet. Med., Thessaloniki, Greece astsing@vet.auth.gr, liliadis@fmenr.duth.gr

Suckling and milking are two stimuli which induce a neuroendocrine reflex. The milk-ejection reflex involves an ascending neuronal pathway from the nipples to the hypothalamus and a descending vascular link that conveys the pituitary hormone, oxytocin, to the mammary gland. Oxytocin is responsible for contraction of the myoepithelial cells surrounding the mammary alveoli. The pattern of oxytocin release exhibits species specific characteristics and can vary significantly. In this paper a prototype Madaline Artificial Neural Network (ANN) model is presented which has been designed and developed to simulate the neural control of the milk-ejection reflex in the sheep, based on the anatomical tracing of the pathway by means of horseradish peroxidase. Tracing of the neural component of the milk ejection reflex in the sheep reveals that the primary afferents innervating the nipples originate from the 2nd to 5th lumbar spinal ganglia, whereas subsequent relay stations of the pathway include either lumbar dorsal horn neurons, the lateral cervical nucleus (LCN), and the paraventricular nucleus of hypothalamus (PVN), or dorsal column nuclei and the PVN. The anatomical data confirm that the transmission of the afferent input from the nipples to the sheep brain is accomplished by at least two pathways that are crossed and polysynaptic. Since the final output of the milk-ejection reflex in the sheep is either oxytocin release or not, the proposed ANN model was designed to contain several Adaline Processing Elements (PE) which offer a bistate output of +1 or -1. The basic Adaline PE consists of a series of trainable weights. A threshold weight (bias) is connected to a fixed input of +1. A Learning mechanism samples the input, the output and the desired output in order to adjust the weights. Since the proposed ANN consists of multiple Adaline PE it is called Madaline (Multiple Adalines). Fuzzy Sets with various membership functions (Triangular, Trapezoidal, Sigmoidal) and proper Linguistics are used to describe the stimuli received by the sheep, like iPressureî, iPainî, iHeatî or iTouchî. Fuzzy conjunction operators are also used to determine the combination of the above stimuli. The real numbers produced (varying from 0 to 1) constitute the Input Vectors to the ANN model. Since Adalines accept only the values -1 and +1 as inputs, the Adaline Linearly Independent Coding scheme was used to convert actual inputs to -1 or +1.

electro-physiological study showed the presence of two antiphasically firing populations of GABAergic neurons in theMSDB (Borhegyi et al. 2004). Other papers described a network of cluster-firing glutamatergic neurons able to generate synchronized activity in the MSDB (e.g., Manseau et al., 2005) We give two different models for theta synchronization in the MSDB. In the first one GABAergic neurons are intrinsic theta periodic oscillators while in the second one they receive periodic input from local glutamatergic neurons. Using computer simulations we show that out-of-phase theta synchrony emerges in the cluster-firing GABAergic neuron network if they form two populations preferentially innervating each other. To test the reliability of our model we studied the response of MSDB neurons to pharmacological modification of GABAergic synapses in anaesthetized rats. Single units from the MSDB, and hippocampal field potential from the CA1 region were recorded. Recordings were made under control condition and after the i.v. application of zolpidem, an alpha-1 subunit selective positive allosteric modulator of the GABA-A receptor. Zolpidem instantaneously disrupt theta oscillation in the septo-hippocampal system and inhibited the firing activity of MS/DB neurons. Our first model could not reproduce directly the effect of zolpidem on the firing activity of MSDB neurons because of the absence of the recurrent connections. In our second model in-phase synchronization of glutamatergic cluster-firing neurons does not requires specific network structure, and these cells are able to act as theta pacemaker for the local fast-firing GABAergic circuit. The condition for out-of-phase synchronization of GABAergic neurons in this system is that only a proportion of fast-firing GABAergic cells are innervated by the glutamatergic neurons. We are currently testing the effect of zolpidem on this model.

### Analyzing the Stability of Turtle Visual Cortex Using Lyapunov Functions for Non-autonomous Systems

Philip Ulinski

Tuesday Poster -T73

The University of Chicago, Chicago, Illinois, USA

pulinski@uchicago.edu

Visual stimuli evoke propagating waves in the visual cortex of turtles that can be studied using voltage sensitive dye methods or simulated in a large-scale model of the cortex. Responses to simulated visual stimuli can be represented by plotting the fraction of cells in each population in the cortex that are active (i.e. firing action potentials) throughout the duration of the cortical response. These activity profiles can be described by a family of linear non-autonomous ordinary differential equations, dX(x,t)/dt = X(x,t)A(t). This paper examines the stability of the system using Lyapunov's theorem for non-autonomous systems, which involves finding a Lyapunov function of the form W(x,t) = X(x,t)TP(t)X(x,t), where P(t) is a matrix that is to be determined. A method of finding P(t) is introduced and used to show that the system described by the large-scale model has a single, stable fixed point and several metastable states.

Inferring neural activity from BOLD via nonlinear optimization		A model of global saliency: Selecting a singleton among distracters	
Vasily Vakorin Gordon Sarty	Sunday Poster –S62	Frank van der Velde Sunday Poster –58 Gwendid van der Voort van der Kleij Pascal Haazebroek	
University of Saskatchewan, Canada, London, Canada		Marc de Kamps	
vav753@mail.usask.ca gordon.sarty@usask.ca		Leiden University, Leiden, The Netherlands	
		vdvelde@fsw.leidenuniv.nl	
The blood oxygen level dependent (BOLD) fMRI sign neuronal activity directly. This fact is a key cause for c		gvdvoort@fsw.leidenuniv.nl	
		We present a model of visual spatial selection (dorsal pathway) that consists of	

response as a physiological function underlying neuronal activity offer the possibility of inferring the timing and amplitude of the neuronal activity from measured BOLD. Specifically, such mathematical models may be used to numerically solve the hemodynamic inverse problem. We propose a new formalism to tackle the issue of extracting the dynamics of the neuronal activity from the measured BOLD signal. It is based on a previously developed spacestate non-linear model of the transduction of neuronal activity into the BOLD response through variables representing the transitional dynamics of the flowinducing signal, cerebral blood flow, cerebral blood volume and deoxyhemoglobin concentration. This mathematical model is considered within the framework of optimization problems. Specifically, the problem under consideration is to find an admissible control or input (the neuronal activity and/or the biophysical parameters in the model) that causes the system to follow an admissible solution that minimizes a performance measure based on modelexperiment discrepancy. This approach is an alternative to a previously published local linearization (LL) filtering scheme which appears to produce erroneous estimations. The method presented here avoids the linearization of the transition system and does not require information on the derivatives. We have found that the dynamics of the neuronal activity, the physiological variables and the biophysical parameters can be reconstructed from the BOLD response by applying global optimization numeric techniques which escape local optima and provide a stable solution. It is also shown that, depending on the choice of basis functions used in the model, the solution may reflect either low frequency local field potentials (LFPs) or spiking neural activity. For future work the results of solving the hemodynamic inverse model can be applied to the dynamic causal modeling (DCM) approach, allowing more meaningful inferences about effective connectivity. Further, when combined with experimental data measuring both the BOLD and electrical activity, we expect that the proposed approach can refine the quantitative assessment of physiological processes.

#### A model of anticipation in the rodent head-direction system

Matthijs van der Meer Sunday Poster - S73 Mark van Rossum

Neuroinformatics DTC, University of Edinburgh, Edinburgh, UK

m.vandermeer@ed.ac.uk mvanross@inf.ed.ac.uk

Head direction (HD) cells in the rodent limbic system fire selectively and persistently when the animal is facing a particular direction in the horizontal plane. Many of these cells do not simply code for current HD, but anticipate the animalís HD by up to 80ms, depending on brain area and details in the experimental protocol and analysis methods used. Previous explanations for this anticipation used offset connections; here we propose an alternative explanation that relies on the firing properties of vestibular (medial vestibular nucleus) neurons thought to provide input to the HD system. We show that spike rate adaptation and post-inhibitory rebound firing in these neurons, as reported in vitro by Sekirnjak and du Lac (2002), can lead to realistic anticipatory time intervals (ATIs) in HD cells. In a single ring attractor network, these input properties also result in small (14h corpus of rat tracking data. When the HD signal is propagated through multiple layers, however, adaptation and rebound act to counter errors caused by low-pass filtering of the signal. In this scenario, the same input properties that give rise to both anticipation and tracking error in early layers can in fact reduce error in later layers. Thus we suggest not only a mechanism, but also a possible advantage for HD cell anticipation. These results have testable predications and are relevant to several other predictive systems.

`a number of interacting spatial maps. It selects the location of a singleton object among a number of distracters. Singleton and distracters differ in shape or color. Both singleton and distracters are locally salient objects, like a red ball (singleton) and blue balls (distracters) on a green lawn. In terms of bottom-up saliency, each object generates strong local activity (local ipop-outi). Yet, the singleton (red ball) also pops-out among the distracters (blue balls). Saliency in this case is global, because the singleton is salient with respect to the entire visual scene. Global saliency occurs with features like color, shape, orientation, and shading. It is not based on local discontinuity, like local saliency. We present a neural model of global saliency that consists of two pathways: ventral and dorsal. The ventral pathway models object identification. Object identity (singleton or distractor) is selected in ventral area AIT. It generates feedback activity, which interacts with stimulus activity in the ventral retinotopic areas, thereby selecting activity related to the objectis location in these areas. This selection (activation) is transmitted to the dorsal pathway. In the dorsal pathway of the model, objects generate activation in an inputi retinotopic map. Activation is location (not identity) related. Each object is salient locally, thus producing similar activation in the input map. The input map activates a icontrastî retinotopic map in a point-to-point manner (i.e., retinotopically). In the contrast map, WTA interaction occurs between different spatial representations. The ventral pathway activates a iventralî retinotopic map, in a point-to-point manner. The ventral map inhibits the representations in the contrast map in a point-to-point manner. The input and ventral map interact in the contrast map, so that the activation (ilocationî) that is not selected (enhanced) in the ventral map is selected. The ventral map also activates a itop-downî retinotopic map (pointto-point). In the top-down map, WTA interaction occurs between different spatial representations. Finally, the contrast and top-down map activate a isaliencyî retinotopic map (point-to-point). In the saliency map, WTA interaction occurs between different spatial representations. In the model, the singletonís location is most strongly activated in the saliency map, when either the singleton or the distracter is selected in AIT. Thus, the singleton wins the WTA competition, and its location is selected.

#### Long-range dependence in spike trains recorded from cerebellar Purkinje cells

Werner Van Geit Erik De Schutter

Tuesday Poster -T62

Laboratory of Theoretical Neurobiology University of Antwerp, Antwerp, Belgium

werner@tnb.ua.ac.be erik@tnb.ua.ac.be

Neural spike trains are in many cases represented as resulting from a renewal Poisson process. This is due to the fact that a lot of interspike interval histograms can be fitted with a Poisson renewal model. However, there are properties of a spike train that cannot be inferred from a histogram. These include the correlation between two successive interspike intervals. In contrast with the classical renewal models, it has been generally known that in recorded neural data, there are indeed such correlations. This is what we also have seen in data recorded from cerebellar Purkinie cells during saccadic eve movements. When the data is compared to spike trains in which the interspike intervals are shuffled a significantly stronger correlation can be seen between successive interspike intervals than in the unshuffled case. In many spiketrains there is a long-range dependence between interspike intervals. This might be due to intrinsic properties of the cells or inhibitory connections from interneurons. But it could also be explained by correlations in the exterior input.

Amplitude equations for a class of neural field models		Hebbian reinforcement learning with stochastic binary synapses follows the reward gradient	
Nikola Venkov	Tuesday Poster – T40	0	
Stephen Coombes		Boris Vladimirski	Sunday Poster – S83
		Eleni Vasilaki	
University of Nottingham, Nottingham, UK		Stefano Fusi	
		Walter Senn	
nikola.venkov@maths.nottingham.ac.uk			
stephen.coombes@nottingham.ac.uk		Institute of Physiology, University of Bern, Bern, Switzerland	

We introduce a generalisation of nonlocal firing rate neural field model in one dimension. It encompasses a number of models from the literature featuring interactions at several spatiotemporal scales, which could be introduced by delays, adaptation or separate excitatory and inhibitory populations. We state the conditions for instability leading to pattern formation for this general integral equation and further derive the amplitude equations at the Turing-Hopf bifurcation. We analyse those equations in order to state general conditions for preference between standing and travelling waves. We are able to show that only two basic configurations of the TW-SW regions in the parameter space are possible, depending on the structure of the model kernels. In parallel with the theoretical development we investigate in detail a single-population model with biologically realistic connectivity (local inhibitory and lateral excitatory connections) and both distributed synaptic delays and space-dependent axonal delays. The neuronal gain is used as bifurcation parameter and we plot the critical value with regard to the axonal propagation speed. We find that for all finite axonal speeds there exists oscillatory Turing instability leading to travelling periodic wavetrains. However for small speeds spatially-uniform oscillations are triggered first by a Hopf bifurcation. The amplitude equations show that travelling waves are prefered for all parameter values. We plot the regions of preference with regard to the axonal speed and the processing function treshold (the neuronal gain is fixed in order to be near the bifurcation). Standing waves are shown to exist but are always unstable. All results are confirmed by simulations of the full model with periodic boundary conditions. Further the application of the general framework we have developed to other models of interest is straightforward. We produce analogous analysis for a model incorporating dendritic cable and a model with spike-frequency adaptation, as well confirmed by simulations.

## Synaptic conductance modulation for correlated activity analysis in networks of spiking neurons

Francisco Veredas Monday Poster – M38 Hèctor Mesa

Dpto. Lenguajes y Ciencias de la ComputaciÛn Universidad de M·laga, M·laga, Spain

fvn@lcc.uma.es westor2@gmail.com

Across the visual pathway strong monosynaptic connections generate precise correlated activity between presynaptic and postsynaptic neurons. The degree of this precise correlated activity can be inferred from the monosynaptic crosscorrelogram peak-width. Retinogeniculate connections generate correlograms with very narrow peaks, while geniculocortical or corticocortical peaks are wider. While it is difficult to determine the physiological parameters that contribute to the precision of the correlated firing in physiological experiments, a first approach can be done by computational modeling and simulation. In this article we present a new integrate-and-fire (IAF) neuron model designed and computationally optimized to analyse the contribution of the main physiological factors to the correlated activity. Our results suggest that the precision of the correlated firing generated by strong monosynaptic connections is mostly determined by the EPSP time course of the connection and much less by other factors. The model stands out to incorporate the modulation of the synaptic conductance based on two alpha functions with different time constants to independently analyse the influence of the rise and decay times of the conductance on the correlated activity. A Z-transformation of the synaptic conductance equation turns it into a recursive function that significantly increases the computational efficiency of the IAF model.

vladimirski@cns.unibe.ch, vasilaki@cns.unibe.ch

Beginning with the pioneering idea of Hebb (1949), much effort has been given to studying learning based on synaptic plasticity. More recently, significant attention has been drawn to making the model networks more biologically plausible and in particular, to adding some stochasticity to the network at the cellular (e.g., node perturbation: Xie and Seung (2004); Fiete and Seung (2006) or synaptic level (e.g., weight perturbation: Seung (2003) in order to stimulate a more complete exploration of the synaptic weight space. However, neurons tend to fire in a regular way given a deterministic input (Mainen and Sejnowski, 1995), which is not directly compatible with cellular-level noise. Seung (2003) used synaptic noise in the realistic form of release probability, but the performance appears relatively slow. Here, we introduce a new synaptic model using feedforward neural network architecture with stochastic, binary synapses. The use of binary synapses is consistent with the results of O'Connor, Wittenberg, and Wang (2005) showing that individual synaptic transmission can be regarded as an all-or-none process. For our model, we propose a Hebbian-like learning rule in which the probability of a synaptic weight change is determined by the reward signal and the correlation between presynaptic and postsynaptic activities. We show that this learning rule implements an approximation of the expected reward gradient over all distinct input patterns. Applying our model to the XOR problem, we demonstrate that the performance is at least as good as that of the node perturbation algorithms and significantly faster than that of the pure weight perturbation algorithms which randomly explore the entire weight space. Our learning rule only explores a very small fraction of the space (for larger networks), hence the increase in speed. Additionally, we introduce a mean-field approximation to our model using analog synapses (the only randomness remaining is in the initial synaptic weights) to study the role of stochasticity in more detail. We find that for larger networks this approximation is good indeed. For small networks, however, the approximation becomes progressively worse, which indicates the positive effect of stochasticity on both convergence and performance. Finally, many other models, including the classical associative reward-penalty algorithm, also maximize the expected reward, but using an individual pattern-dependent threshold, which implies that the synapse somehow "knows" which pattern is being applied. Our learning rule appears qualitatively more realistic since it only uses an LTP/LTD threshold parameter averaged over all distinct input patterns.

## Effect of Asynchronous GABA Release on the Oscillatory Dynamics of Inhibitory Coupled Neurons

Thomas Voegtlin Dominique Martinez Monday Poster -M82

INRIA, Vandoeuvre-les-Nancy, France voegtlin@loria.fr, dmartine@loria.fr

Recorded electrical signals, such as electroencephalograms or local field potentials, often exhibit rythmic activity patterns, with a frequency that often changes from one band to another. These oscillations can be reproduced in network models of coupled inhibitors. However, the mechanism that controls the period of the oscillations is not fully understood. Recent studies have shown that there are various types of inhibitory interneurons. More precisely, inhibitory cells may release transmitters synchronously or asynchronously. Could this diversity explain changes of the rythm of the oscillation? To answer this, we used a simplified model of the mammal olfactory bulb (OB), consisting of a network of coupled inhibitory neurons. We tested the effect of synchronous versus asynchronous inhibition in this model, using computer simulations. We observed that frequency is reduced when release is asynchronous. This suggest that the release mode of GABA could play an important role in setting up the oscillatory frequency in inhibitory coupled neurons.

Signal Propagation and Switching in Networks		Astrocyte modulation of synaptic transmission - autapse as a case study	
Tim Vogels Larry Abbott	Sunday Poster –S74	Vladislav Volman Monday Poster -M89 Eshel Ben-Jacob Herbert Levine	
Brandeis University, Columbia University New York, New York, United States		School of Physics & Astronomy, Tel-Aviv Univ., Tel-Aviv, Israel	
vogels@brandeis.edu lfa2103@columbia.edu		hamlet@tamar.tau.ac.il eshel@tamar.tau.ac.il	
Signaling between different brain areas is essential for cognitive function, but reliable target-specific signal propagation without large-scale synchronization is difficult to achieve in network models. We build and study randomly connected, sparse networks of integrate-and-fire neurons and show that they generate sufficient background activity to support signal transmission. We characterize the fidelity and range of signal propagation in such networks as a function of the magnitude and variability of synaptic weights, connectivity patterns, and other relevant parameters. Cognitive function and motor action also require mechanisms that gate and control the flow of information. We introduce gating mechanisms within the networks we study in two ways. First, we consider the neural analog of logic gates. These can arise within the architecture of random networks through the strengthening of specific synapses, and they make it possible to direct propagating signals by means of additional activity. A second mechanism relies on a "detailed balance" of the excitatory and inhibitory effects of a particular signal ing pathway. By manipulating this balance, a control signal can allow or disallow signal propagation from one area of a network to another,		We present a simple biophysically tractable model for the coupling between synaptic transmission and the local calcium concentration on an enveloping astrocytic domain. This interaction enables the astrocyte to modulate the information flow from pre-synaptic to post-synaptic cells in a manner dependent on previous activity at this and other nearby synapses. We explored the possible consequences of this modulation for an astrocyte-gated autaptic oscillator, arguably the simplest possible neuro-glia circuit. For this apparently simple model system, we found that astrocyte modulation of autaptic transmission results in the irregular burst-like spiking statistics of a model neuron, manifested in the long-tailed distribution of spiking events times. In addition, the shape of the distribution tail can be modulated by the profile of calcium oscillations in the adjacent astrocyte. Our model suggests a novel, testable hypothesis for the spike timing statistics measured for rapidly-firing cells in culture experiments.	
thereby acting as a gate. Anatomy-based network models of cortex and their	statistical analysis	Sensitivity analysis of neuronal firing to morphologic and spatially extended intrinsic properties	
Nicole Voges	Tuesday Poster – T67	Christina Weaver Monday Poster – M74 Susan Wearne	
Ad Aertsen Stefan Rotter		Mount Sinai School of Medicine, New York, New York, USA	
Inst. Bio III, AL. Universitaet Freiburg, Freiburg, Ger	many	christina.weaver@mssm.edu susan.wearne@mssm.edu	
nicole.voges@biologie.uni-freiburg.de aertsen@biologie.uni-freiburg.de Most current studies of cortical network dynamics assu wiring, a very practical but presumably too simplistic a structure of cortex is much more complicated, in partic local and long-range connections, and special features cell-type specific couplings. In this study we investiga alternative network architectures which may eventually cortical network models. First, in order to enable distar connectivity, we assumed an embedding of all neurons geometry of dendrites and axons. To assess the influen embedding on network topology we considered both ra and regular lattices. The wiring comprised local and no various compositions. The parameters of all models we full continuum from local/regular to completely randor we employed the framework of stochastic graph theory characteristic network properties. For example, we ana distribution, clustering coefficient and average shortest networks, as well as the spectrum of eigenvalues and th eigenfunctions of the corresponding adjacency matrice quantitatively study the impact of statistical neuro-anat compare our enriched cortical networks. In a compa models we show that the global graph-theoretic proper networks may be vastly different. Especially, the abunc connections is a crucial point, potentially leading to dra network topology. In addition, the modalities of the spa important as they strongly influence the variance of de In conclusion, we began to identify a set of parameters networks like the neocortex as an integrated system, he neuro-anatomical data, and to develop new network mo understanding of cortical function	pproach. The network alar, it comprises both ike patchy projections or led and compared several lead to more realistic ce dependent in space, reflecting the ze of the spatial ndomly positioned nodes n-local connections in re arranged to span the n connectivity. Second, to define a set of yzed the degree path length of our e locality of the s. This enabled us to omical knowledge, and to well-known types of rative study of these ies of the resulting lance of non-local matic changes in tial embedding are grees across the network. that characterize large lping to better interpret	Mathematical models are used frequently to elucidate the physiological mechanisms underlying experimentally observed behavior. Towards that end, it is valuable to know which model parameters contribute most to model output in some quantitative way. Our interest lies in understanding how dendritic morphology and spatially extended intrinsic properties contribute to the firing behavior of compartmental models. Various interactions between the parameters are most important. To investigate such parameters simultaneously, local sensitivity analysis techniques are used within a parameter space defined by both morphologic features and spatially extended intrinsic properties. These methods allow comparison of the sensitivity of neuronal model output to various parameters, regardless of parameter unit and magnitude. These sensitivity analysis techniques are demonstrated on a compartmental model composed of a soma and a single equivalent dendrite. Perturbations are made to the surface area, length, and diameter of the dendrite while controlling for associated changes in active channel densities and numbers. For comparison, spatially distributed dendritic ion channel densities and parameters consistently have a strong effect on AHP shape and firing rate to each parameter is computed at several points in parameter space. Important these in parameter space. Importantly, our data show that there are regions in parameter space in which morphologi parameters have a greater effect on model output than spatially extended properties that are purely conductance-related. Analysis of the effects of dendritic length, diameter, and surface area shows that these three parameters combine to influence AHP shape and firing rate in different ways. These findings lead to a greater understanding of how morphologic and spatially extended intrinsic properties maters are regions in parameters bareater combine to influence AHP shape and firing rate in different ways. These findings lead to a greater understanding of how morphologic and spatially	

A cell assembly model for complex behaviour		STEPS: Stochastic Simulation of Reaction-Diffusion in Complex 3-D Environments	
Thomas Wennekers	Tuesday Poster –T65	Stefan Wils	Sunday Poster – S53
Centre for Theoretical and Computational Neuroscience, University of Plymouth, Plymouth, UK	,	Erik De Schutter	Sunday FOSIEI –555
thomas.wennekers@plymouth.ac.uk		Theoretical Neurobiology Lab, Wilrijk, Belgium	
thomas.wennekers@plymouth.ac.uk Hebbian Cell Assemblies have been proposed as a model for brain processes at the interface of physiology and psychology. The theory claims that the experience of concrete objects and more abstract entities is due to neural representations in the brain consisting of strongly connected ensembles of cells that fire invariantly if the represented construct is a matter of (conscious) experience. Recently there has been an amazing progress in discovering new results concerning spatio-temporal short-term memory and the organisation of coordinated behaviour in space and time likely layed down in prefrontal and adjoined areas. It is not at all clear if and how the somewhat attractor-centered assembly theories are a proper model also for the representation of such complex sequences of behavioural patterns. In the present work we will argue that indeed there is only a single conceptual principle missing in the Hebbian paradigm on top of auto- and hetero-associative connection pathways in order to cover many of the recent findings on complex behavioural sequencing. This principle consists of input-gated transitions between brain states (as static attractors or SFCs). We show, however, that the simplest notion of gated transitions as proposed by others, where states plus an input (external or context) lead to the activation of target states is not sufficent for generic circuits. Instead we propose an alternative that allows to represent and process virtually arbitrary cognitive tasks. Example simulations using a multi-area neural network of spiking neurons comprising layered models of V1, IT, PFC & PMC will be		<ul> <li>stefan@tnb.ua.ac.be</li> <li>erik@tnb.ua.ac.be</li> <li>Quantitative modeling of chemical signalling in neurob challenges, that are not adequately addressed by mass a issue, one that is encountered in many other fields of bic character of many reaction systems. The presence of pothe reaction network can amplify the probabilistic occur intensity reactions, eventually affecting the behaviour of macroscopic scale. Two challenges that are more specific the extremely complex nature of neuronal morphology, functionally relevant spatial gradients and chemical con the complex composition of membrane structures, whic of complicated boundary conditions. Our simulation so developed specifically to deal with these issues.</li> <li>Development of receptive fields in a closed loop behate Florentin Woergoetter Tomas Kulvicius Bernd Porr</li> </ul>	ction kinetics. The first ology, is the noisy sitive feedback loops in rrence of certain low of the system on a to to neuroscience are which can lead to npartmentalization, and h requires the modeling ftware, STEPS, has been
distributed assemblies in order to solve high-level cognit	ive tasks.	BCCN, Goettingen, Germany	
Resonance tuning of a neuromechanical system with feedback configurations	two negative sensory	worgott@chaos.gwdg.de tomas@chaos.gwdg.de	
Carrie Williams Stephen DeWeerth Georgia Institute of Technology, Atlanta, Georgia, USA cwilliam@ece.gatech.edu steve.deweerth@ece.gatech.edu We compare the resonance tuning of a simple model of the has neural and feedback dynamics similar to those found lamprey swim system. Overall, the model includes a halt central pattern generator (CPG) that is coupled through f feedback signals to a linear, one-degree-of-freedom mec CPG receives two different negative feedback inputs tha position of the mechanics: an inhibitory input to the activ oscillator, and an excitatory input to the inactive side. In neurons of the half-center oscillator can be tonically spik bursting depending on the simulated activation of the net and concomitantly implementing the negative feedback of that (1) the closed-loop system tunes to a different range frequencies with negative, inhibitory versus negative, ex that concomitant implementation of the two feedback co shifts the resonance tuning range, and (3) that the underlinfluences the range of resonant frequencies to which the given feedback configuration.	hythmic movement that li none segment of the f-center oscillator for a 'eedforward and hanical subsystem. The t are related to the ve side of the half-center addition, the individual ing or intrinsically twork. By individually configurations, we show of mechanical resonant citatory feedback, (2) nfigurations effectively ying activity of the CPG	In higher vertebrates sensor and motor pathways conver- stages. On the other hand, recently it has been pointed of like flies a motor neuron can have indeed a visual recep- Huston, Proc. German Neurosci. Conf., pg. 16-3, 2005) directly generate behaviour and the induced actions of t change its sensory perception thereby closing the loop. animals one could stretch the argument saying that ever necessarily has - in a very indirect way - a sensory recep- that it is directly possible to develop receptive fields in behavioural systems by ways of a correlation based seq algorithm. The main goal is to demonstrate that learning behaviour and that the resulting receptive fields are also newly learned behaviour is successful. In the second pa implement simple chained learning architectures, demo results can also be obtained in this case, even for second which mostly receive indirect visual input. The develop unchanging neuronal properties in a stable behavioural difficult problem because convergence of functional ne behaviour has to be guaranteed at the same time. This s towards a solution of this problem shown by a simple re presented here suggest that it seems to be possible to ac and functional development also in more complex archi ecological embedding of the learning neuronal system i	but that in simple animals tive field (Krapp and . Such receptive fields he animal will in turn Even in more complex y motor neuron ptive field. We will show simple closed-loop uence learning g generates stable o stable as soon as the rt of this study, we nstrating that similar dary receptive fields, ment of structured and context represents a uronal properties and of tudy is a first attempt obot system. The results hieve stable structural itectures by rigorous

Homeostatic regulation of neuronal excitability, correlated patterns and global attractors	Hierarchical Multivariate Analysis of Variance for electrophysiological data	
Steve Womble Tuesday Poster – T82	Jianhua Wu Sunday Poster –S37 Jianfeng Feng	
University of Leeds, Leeds, UK	University of Warnight Country IIV	
womble@comp.leeds.ac.uk	University of Warwick, Coventry, UK jianhua.wu@warwick.ac.uk, jianfeng.feng@warwick.ac.uk	
In this paper we show that homeostatic regulation of neuronal excitability is sufficient to prevent the emergence of global attractors in simple biologically constrained neuronal networks when exposed to Hebbian plasticity and significantly correlated activity patterns. The model is based on gain adaptation, multiplicatively scaling input activity, and is a caricature of a well known mechanism believed to regulate neuronal excitability through adaptation of the quantal amplitude of the AMPA-receptor excitatory pathway. It is shown that in the parameter regime for which gain adaptation is a successful homeostatic regulator, Hebbian learning endows a simple but biologically constrained neuronal network with the ability to perform prototype extraction, given noisy inputs. Outside of this parameter regime and in the absence of adaptation it is shown that as expected due to significant correlations in the input patterns global attractors emerge. The results go some way to suggest how neocortical networks may function as associative networks under Hebbian plasticity without the need for `computational fixes' to the global attractor problem for which there	A hierarchical multi-variate analysis of variance (MANOVA) test to statistically analyze changing patterns of multi-electrode array (MEA) electrophysiology data is developed. The approach enables us not only to detect significant mean changes, but also significant correlation changes in response to external stimuli. Furthermore a method to single out hot-spot variables in the MEA data both for the mean and correlation is provided. Our methods have been validated using both simulated spike data and recordings from sheep inferotemporal cortex. <b>Robust Coding and Its Implication on Neural Information Processing</b> Si Wu Sheng Li Dept. of Informatics, Sussex University, Brighton, UK	
is no concrete currently evident anatomical analogue in the neocortex.	siwu@sussex.ac.uk, sheng@sussex.ac.uk	
Effects of Electrical Coupling on Excitatory Coupled Pacemaker Neurons in the pre-Bötzinger Complex Terrence Wright, Jr. Monday Poster –M1	In natural environments, variations on the view angle, distance and background, and deformations of images, mean that the external inputs from the same object to neural systems are highly fluctuated. In order to recognize objects reliably, it is important for neural coding to be robust to noise. Two issues concerning the robustness of neural codes are explored in the present study. Firstly, we identify	
Robert Butera	what are the factors influencing the robustness of neural coding, and find that	
Program in Neuroscience, Emory University Laboratory for Neuroengineering, Geogia Tech, Atlanta, Georgia, USA	the overlap between neural receptive fields plays a critical role, i.e., the larger the overlap, the more susceptive to noise the neural responses are. This property implies that for achieving robust coding, neural systems should use receptive fields having as small as possible overlap (under the proviso that external	
terrence.m.wright@emory.edu rbutera@ece.gatech.edu	objects are adequately encoded). Secondly, we construct a robust coding scheme, which enforces the neural responses not only encode external inputs well, but also have limited variability. Based on this scheme, we investigate how	
A key component of the neural circuit for the generation of the respiratory rhythm in mammals is the pre-B'tzinger Complex (or pBC), located in the ventrolateral medulla of the brainstem .A subclass of pBC respiratory neurons that have intrinsic membrane properties, termed pacemaker neurons, are hypothesized to underlie rhythmic oscillatory bursting as these cells possess a persistent sodium current with slow inactivation kinetics. Recent evidence suggests a role for electrical coupling within the network. These findings implicate electrical coupling as a potential contributor to the generation of the respiratory rhythm. We have previously developed a minimal model of pacemaker neurons found in the pBC that showed that a heterogeneous excitatory network of these cells could generate synchronous bursting consistent with the type of rhythmic bursting observed in in vivo. These previous works	neuronal receptive fields are shaped in order to encode natural images accurately. It turns out that the obtained results resemble the localized and oriented receptive fields of simple cells in the striate cortex. This finding is interesting, which provides a novel justification for the receptive field properties of simple cells, different from those in the literature based on sparse coding, temporal coherence and independent component analysis. We also compare the difference between robust and spare coding, and find that although they generate the same, or similar, optimal basis functions for encoding natural images, their properties in neural responses are different, namely, the neural responses in the former case are much more robust to noise. Some general implications of robust coding on neural information processing are also discussed.	
did not include electrical coupling. Therefore, the current work attempts to address the effects of electrical coupling on synchronous bursting activity. Previously, we conducted a systematic approach where we varied electrical coupling in the presence and absence of synaptic coupling. Our initial results	Performance-dependent changes of spike and LFP in monkey prefrontal cortex during short-term memory	
suggested low electrical coupling is sufficient for burst synchronization, and that at sufficient strengths of electrical coupling, spikes synchronize in phase within a burst and the frequency of bursting increases. These model results appear similar to those described as symmetric and asymmetric bursting in Best et al. (2005). We also explored the applied stimulus range (defined as the range of	Wei WuSunday Poster -S103Diek W. WheelerEllen Stadtler, Matthias Munk, Gordon PipaFIGSS, Frankfurt am Main, Germany	
lapp required to drive both cells to silence and to tonic spiking) of coupled	wu@figss.uni-frankfurt.de, wheeler@fias.uni-frankfurt.de	
pacemaker cells in the presence and absence of synaptic coupling and with synaptic coupling. Low, but not high, values of electrical coupling generally yielded higher applied stimulus ranges. These results suggest that the parameter space where synchronous bursting occurs is larger in the parameter regime of low values of electrical coupling. These issues are important in that the respiratory central pattern generator must output a wide range of frequencies, and this system is controlled in part by a modulated level of background input referred to a irespiratory drive.î Our current efforts are focused on eliciting how robust the input and output space are in these two bursting regimes and elucidating the mechanisms whereby the phase of spike synchronization affects burst frequency.	Since local field potentials (LFPís) represent mostly presynaptic activity and spikes are postsynaptic events, we hypothesized that their time courses would differ during neuronal processing. In this study, we compared the power and coherence of LFP and spikes as a function of time in two different frequency bands in recordings from the prefrontal cortex of monkeys performing a short-term visual memory task (0.5 s sample, 3 s delay, 2 s test presentation). We found that significant increases in LFP and spike power occurred at different times in recordings from monkey prefrontal cortex during a short-term memory task. Differences were found in both the theta and gamma bands. We also computed LFP-LFP and LFP-spike coherences and determined that there is a strong correlation between LFP and spikes during correct performance of the memory task.	

Hierarchical neurogenetic model of LFP generation: from genes to neural oscillations	Homeostatic Scaling of Excitability in a Neuron with Spike Timing- Dependent Plasticity
Simei Wysoski Tuesday Poster – T30 Lubica Benuskova Alessandro Villa Nikola Kasabov	Fleur Zeldenrust Tuesday Poster – T78 Michiel Remme Wytse Wadman
KEDRI Auckland University of Technology, Auckland, , New Zealand	SILS-CNS, Amsterdam, The Netherlands
swysoski@aut.ac.nz Ibenusko@aut.ac.nz	fleur.zeldenrust@student.uva.nl remme@science.uva.nl
With the recent advancement of genetic research and with successful sequencing of the human genome and other genomes, more information is becoming available about the interaction between brain functions and genes, about genes related to brain diseases and about gene-based treatment of them. It is well accepted now that brain functions are better understood and treated if information from molecular and neuronal level is integrated. For this purpose, computational models that combine genetic and neuronal information are needed for modelling and prognosis. Such models are called here computational neurogenetic models (CNGM). Genetic studies show that human EEG has a strong genetic basis. That is, the EEG spectral characteristics are strongly preserved within families as well as in individuals. Since EEG is the sum of many local field potentials (LFPs) mainly from the cerebral cortex, and brain LFPs have the same spectral characteristics as EEG, we assume the same genetic basis for LFP as for EEG. We present a hierarchical model of LFP generation which has the following components: neuronal genes and their expression levels; protein expression levels; interactions between genes; receptor and ion channels related functions; generation of electric signals; generation of a local field potential (LFP). We introduce step by step: (1) how to link parameters of a neural model to activities of genes/proteins, (2) which genes/proteins are to be included in the model, (3) how to model gene/protein dynamics, (4) how to validate the model on the real brain data, (5) what kind of new and useful information about neural gene interactions can be derived by	In an analytical study we investigated the effect of homeostatic scaling of excitability (HSE) in a neuron in which synaptic efficacy depends on the timing of pre- and postsynaptic spikes. This type of learning is known as spike timing-dependent plasticity (STDP). Although the latter form of use-dependent learning is experimentally confirmed it is not necessarily stable. Its additive form leads to a bimodal distribution of synaptic weights, while its, biologically more plausible, multiplicative form needs to be stabilised by a normalising mechanism. We implemented a mechanism for controlling the output frequency inspired by experimental data that describe such a system in the hippocampus (van Welie et al., 2003). Next we investigated whether the HSE system interferes with the learning procedures of STDP by analytical calculation of the synaptic weights that result when the STDP synapses are stimulated with spike trains that include (partial) correlations. Under control conditions the neuron will detect such correlations. Superimposing a mechanism for HSE on top of the STDP did not disturb the ``learning process''. Several variations in input patterns were investigated. HSE and STDP together are capable of stabilizing the output frequency of the neuron, while it maintains sensitivity to input correlations at the same time.
means of CNGM.	Jiaxiang Zhang Sunday Poster –S60 Rafal Bogacz
The Effect of Cannabinoids on Sensory Gating: a Neural Network Model Study	University of Bristol, UK Bristol, UK
Margarita Zachariou Tuesday Poster –T31 Stephen Coombes Rob Mason	jx.zhang@bristol.ac.uk rafal@cs.bris.ac.uk
Markus Owen University of Nottingham, Nottingham, UK	Abstract Many decision making models have been proposed to describe the neuronal activity in a two alternative choice paradigm. Due to evolutionary pressure, the values of the parameters of these models which maximize their
pmxmz@nottingham.ac.uk stephen.coombes@nottingham.ac.uk Gating of sensory (e.g. auditory) information has been demonstrated as a reduction in the auditory- evoked potential responses recorded in the brain of both normal animals and human subjects. Auditory gating is perturbed in schizophrenic patients and pharmacologically by drugs such as amphetamine, PCP or ketamine, which precipitate schizophrenic-like symptoms in normal subjects. The neurobiological basis underlying this sensory gating has recently begun to be investigated using multiple microelectrode arrays (MEAs). In this poster I will present some MEA electrophysiological data from the Nottingham Neuronal Networks Electrophysiology Laboratory and show how we are using advanced computational and mathematical techniques for the analysis, presentation and interpretation of such data. A biophysically realistic model of the CA3 region of hippocampus, known to be involved in generating the auditory evoked potential response associated with sensory gating, has been developed to investigate the neurobiology of sensory gating. In particular, the role of Cannabinoids will be discussed.	pressure, the values of the parameters of these models which maximize then accuracy are likely in biological decision networks. Such optimal parameters have been found for the linear versions of these models. However, in these linear models the firing rates of integrator neurons may achieve arbitrarily high and thus biologically unrealistic values. This paper analyses the one-dimensional Ornstein-Uhlenbeck (O-U) model with two types of restrictions on maximum firing rate proposed in the literature: reflecting and absorbing boundaries, which are able to confine the neural activity within certain interval and hence to make the original model more biologically realistic. We identify the optimal value of the linear parameter of the O-U model (typically denoted by lambda): it is positive for the model with reflecting boundaries and negative for the model with absorbing boundaries. Furthermore, both analytical and simulation results show that the two types of bounded O-U models hold close relationship and can achieve the same maximum accuracy under certain parameters. However, we claim that the decision network with absorbing boundaries is more energy efficient. Hence due to evolutionary pressure our analysis predicts that in biological decision networks, the maximum firing rate is more likely to be limited by absorbing rather than reflecting boundaries.

# Modeling Recovery of Rhythmic Activity: Hypothesis for the role of a calcium pump

Yili Zhang	Monday Poster – M63
Jorge Golowasch	
Computational Biology, Harrison, New Jersey, USA	
<u>yilizh@yahoo.com</u> , golowasch@stg.rutgers.edu	

The rhythmic activity produced by the pyloric network of crustaceans depends on the release of neuromodulatory substances by axon terminals from adjacent ganglia. After these terminals are destroyed or action potential transmission along these axons is inhibited (decentralization), rhythmic pyloric activity recovers spontaneously, but the process of activity recovery follows a very complex temporal dynamics that involves the alternating turning on and off of the pyloric rhythm (termed iboutingî). This bouting period lasts several hours after which a stable pyloric rhythm reemerges. A previous theoretical study used a network model to characterize the process of activity recovery after decentralization. This study showed that long-term activity-dependent regulation of ionic conductances was necessary and sufficient to enable this recovery. However, it did not capture the complex temporal dynamics that follows decentralization and that precedes the final stable recovery. Here we built a model of a single conditional pacemaker neuron whose ionic conductances as well as the activity of Ca++ uptake into internal stores are slowly regulated by activity. To this end we used a model similar to the one previously described but included a simple yet realistic network of intracellular Ca++ sequestration into, and release from, intracellular stores via a Ca++ pump and IP3-dependent Ca++ channel. Intracellular Ca++ sensors, meant to represent enzymatic pathways, regulate the Ca++ pump activity as well as the maximal conductances of Ca+ and K+ channels. This model correctly reproduces the dynamic process of bouting that leads to the stable rhythmic state observed in the biological system. This model suggests that the role of Ca++ sequestration plays an important role in the process of activity recovery, via either intracellular Ca++ pump regulation or the regulation of Ca++ release from intracellular stores. These are predictions that should now be tested experimentally. Supported by NIMH 64711 and NSF IBN-0090250.

### Efficient stereo coding in the primary visual cortex and its experimental tests by optical imaging and single cell data

Li Zhaoping Sunday Poster –S23 Mark Hubener, Akiyuki Anzai Department of Psychology, University College London, London, UK z.li@ucl.ac.uk, mark@neuro.mpg.de

Recoding sensory inputs to remove the input redundancy has been advocated as a sensory preprocessing goal(Barlow 1961). An overwhelming source of redundancy in visual inputs is the pair-wise image pixel correlation, and the binocular correlation in particular. It is redundant to transmit the correlated inputs from the two eyes independently to the cortex, and it has been proposed that V1 cells de-correlate the binocular inputs to improve coding efficiency (Li and Atick 1994). This means, the V1 cells recode or combine the retinal inputs from the two eyes such that the cell outputs would be less correlated while preserving input information. In particular, this leads to the following consequences. (1) when the inputs from the two eyes are almost identical, such as arising from horizontal bars which typically have near zero vertical disparities, they are summed into binocular cells rather than redundantly and separately coded by two monocular cells; (2) when the inputs from the two eyes are more different, such as arising from bars oriented vertically, monocular or ocularly unbalanced V1 cells will extract the difference between the two retinal inputs and thus the stereo information; (3) when the retinal inputs are very weak, e.g., when received by cells of smaller receptive fields or tuned to higher spatial frequencies, they are summed into binocular cells in order to increase signal-tonoise. This efficient code predicts that V1 cells tuned to horizontal orientation or to higher spatial frequencies are more likely binocular than cells preferring other orientations or spatial frequencies. To test these predictions, we examined the data obtained by optical imaging (Hubener et al 1997) and electrophysiological recordings (Anzai et al 1995) of the cat V1. By presenting visual stimulus of different orientations and spatial frequencies through different eyes, the preferred orientations, spatial frequencies, and ocular dominance were obtained for single cells, or the local cortical areas of the optical images. In the optical images from four cats, we examined the proportion of image pixels that are more binocular among all the pixels tuned to particular orientation or spatial frequency and confirmed both predictions. In the electrophysiological data from 136 V1 cells, we obtained distributions of ocular balance indices for cells tuned to different ranges of orientations. We confirmed the predicted association between horizontal orientation preference and binocularity. Our experimental results confirmed the theoretical predictions, thus supporting the hypothesis of efficient stereo coding as one of V1ís the roles.

### Neuromodulation of short-term synaptic dynamics examined in a mechanistic model

Lian Zhou Shunbing Zhao Farzan Nadim Tuesday Poster – T89

Sunday Poster - S75

Rutgers University, Piscataway, New Jersey, USA

linkerhxh@gmail.com shunbing@gmail.com

Network plasticity arises in large part due to the effects of exogenous neuromodulators. We investigate the neuromodulatory effects on short-term synaptic dynamics. The synapse from the lateral pyloric (LP) to the pyloric dilator (PD) neuron in the pyloric network of the crab C. borealis has spikemediated and non-spike-mediated (graded) components. Previous studies have shown that the graded component of this synapse exhibits short-term depression. Recent results from our lab indicate that in the presence of neuromodulatory peptide proctolin, low-amplitude presynaptic stimuli switch the short-term dynamics of this graded component from depression to facilitation. In this study, we show that this facilitation is correlated with the activation of a presynaptic inward current. This inward current is blocked by Mn2+ suggesting that it is a slowly-accumulating Ca2+ current that appears in the presence of bath-applied proctolin. We incorporate this new current, as well as additional modification, into a model of synaptic release and examine mechanisms underlying the neuromodulatory actions of proctolin on the short-term synaptic dynamics. We modify a Ca2+-dependent mechanistic model of synaptic release, previously presented at this meeting, by assuming that the low-voltage-activating Ca2+ current in our system is composed of two currents with distinct kinetics (one rapidly activating/inactivating ICaF, and another slowly activating/inactivating ICaS), as has been shown in other systems. One action of proctolin in the model is to adjust the activation rate of ICaS, which leads to accumulation of local intracellular Ca2+ in response to multiple presynaptic voltage stimuli. This accumulation in turn results in synaptic facilitation. Additionally, we assume that proctolin increases the maximal conductances of Ca2+ currents in the model, consistent with the increased synaptic release found in the experiments. We find that these two presynaptic actions of proctolin in the model are sufficient to describe its actions on the short-term dynamics of the LP to PD synapse.

#### Desynchronization in diluted neural networks

Ruediger Zillmer Roberto Livi Antonio Politi Alessandro Torcini

INFN Sez. Firenze, Sesto Fiorentino, Italy

zillmer@fi.infn.it livi@fi.infn.it

The dynamical behaviour of a dilute fully-inhibitory network of pulse-coupled spiking neurons is investigated in details. Depending on the amount of coupling two different phases can be observed. At low coupling a frequency locked phase is identified: in this regime all neurons fire with the same rate. By increasing the coupling a second phase emerges, where the neurons tend to desynchronize. In both phases the dynamics can be proved to be dynamically stable and indeed after a transient it converges towards a periodic state. However, the evolution in the unlocked phase is characterized by a transient regime whose duration grows exponentially with the system size and whose dynamical evolution reveals a clear erratic character. During the transients one observes irregular firing sequences with a Poisson-like distribution of the inter-spike intervals. Such behavior has so far been attributed to dynamically unstable chaotic networks. e.g., with balanced excitatory and inhibitory activity. The mechanism of the desynchronization is directly related to the weak disorder introduced by the random dilution. Thus we expect the effect to emerge in a wider class of disordered models, including, e.g., excitatory connections. The observed stationary transients might play a crucial role in neurobiological computation, since they combine reliability (dynamical stability) with a high information content (irregular firing sequences).

### **R**EVIEWERS

Aaron Gruber (USA) Alessandro Treves (Italy) Alessandro Vato (USA) Alex Roxin (Spain) Alexander Borst (Germany) Alexander Dimitrov (USA) Alexander Komendantov (USA) Alfonso Renart (USA) Alla BorisyUK (USA) Amir Karniel (Israel) Amitabha Bose (USA) Anna Moritz (USA) Arjen Vanooyen (Netherlands) Asya Shpiro (USA) Aurel Lazar (USA) Ben Torben-Nielsen (Netherlands) Benjamin Lindner (Germany) Bill Holmes (USA) Bradley Wyble (UK) Brent Doiron (USA) Bruce Graham (UK.) Carl Van Vreeswijk (France) Cengiz Gunay (USA) Christiane Linster (USA) Christina Weaver (USA) Daniel Durstewitz (UK) David Redish (USA) Dezhe Jin (USA) Dieter Jaeger (USA) Don Johnson (USA) Eckehard Olbrich (Germany) Elhanan Borenstein (Israel) Erik Fransén (Sweden) Fabrizio Gabbiani (USA) Francesco Battaglia (Netherlands) Gabriel Kreiman (USA) Gergo Orban (Hungary) Gustavo Deco (Spain) Hans Plesser (Norway) Hide Cateau (Japan) Hidetoshi Ikeno (Japan)

Hiroaki Wagatsuma (Japan) Hiroshi Okamoto (Japan) Horacio Rotstein (USA) Hualou Liang (USA) Ildiko Aradi (USA) Jaap Vanpelt (Netherlands) James Bednar (UK) Janet Best (USA) Jean-Marc Fellous (USA) Jeffrey Mckinstry (USA) Jeremy Caplan (Canada) John Lewis (Canada) Jonathan Pillow (UK) Jose Ambros-Ingerson (USA) Kazuhisa Ichikawa (Japan) Kurt Ahrens (USA) Leslie Kay (USA) Leslie Smith (UK) Linda Larson-Prior (USA) Lyle Graham (France) Maciej Lazarewicz (USA) Maneesh Sahani (UK) Marc-Oliver Gewaltig (Germany) Marja-Leena Linne (Finland) Mark E. Nelson (USA) Markus Diesmann (Germany) Martin Paul Nawrot (Germany) Maxim Bazhenov (USA) Michael Hasselmo (USA) Michelle Rudolph (France) Mike Oram (UK) Naoki Masuda (Japan) Nicolas Fourcaud-Trocmé (France) Niklas Ludtke (UK) Paolo Delgiudice (Italy) Patrick Crotty (USA) Paul Miller (USA) Paul Tiesinga (USA) Pawelzik Klaus (Germany) Peter Andras (UK) Peter Dayan (UK)

Peter Erdi (USA) Philip Ulinski (USA) Ramana Dodla (USA) Ranu Jung (USA) Robert Butera (USA) Robert Calin-Jageman (USA) Roberto Fernández galán (USA) Ruben Tikidji-Hamuryan (Russia) Ruggero Scorcioni (USA) Samat Moldakarimov (USA) Simon Schultz (UK) Sonja Gruen (Germany) Stan Gielen (Netherlands) Stefan Rotter (Germany) Steven Bressler (USA) Steven Schiff (USA) Szabolcs Kali (Hungary) Theoden Netoff (USA) Tim Lewis (USA) Udo Ernst (Germany) Upinder Bhalla (India) Victoria Booth (USA) Vincent Hakim (France) Vladimir Brezina (USA) Vladimir Itskov (USA) Volker Steuber (UK) Walter Senn (Switzerland) Wilson Truccolo (USA) Yuguo Yu (USA) Yukata Sakai (Japan)