Institute for Neural Computation

INC

Annual Review of the Organized Research Unit
Fiscal Year 2009

The University of California, San Diego
Institute for Neural Computation
SDSC East Expansion

UCSD Official web page of the University of California, San Diego

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GENERAL INFORMATION

Description	**The Institute for Neural Computation has the mission of bringing together the diverse community in the basic sciences, medical, and engineering disciplines at UC San Diego in advancing and promoting a new science of computation. This science is based on the multiscale, parallel, and highly adaptive architectures found in biological neural systems. The INC is committed to worldwide leadership in its research and to work with industrial partners, as well as the broader community in applying research advances to the benefit of society.**
URL	**http://inc2.ucsd.edu/**
Admin Phone	**(858) 534-7880**
Admin Fax	**(858) 534-2014**
Admin Mailcode	**0523**
Admin Location	**SDSC East Expansion**
Year Established	
Org Codes	**418717** Core (instruction, research, public service) **434997** Academic support (academic department administration) **438717** Academic support (academic department administration) **788717** Finanical aid, graduate
Home Unit Codes	**208**

STAFFING

ADVISORY COMMITTEE

(5)

First Name	Last Name	Home Department	Appt. Date	End Date
Gert	Cauwenberghs	Neurobiology	1/1/2008	6/30/2010
Andrea	Chiba	Cognitive Science	7/1/2009	6/30/2011
Patricia	Churchland	Philosophy	7/1/2001	6/30/2009
Garrison	Cottrell	Computer Science	7/1/2001	6/30/2009
Jerome	Swartz		7/1/2008	

DIRECTORS

(2)

First Name	Last Name	Home Department	Appt. Date	Appt. End
Gert	Cauwenberghs	Neurobiology	7/1/2008	6/30/2013
Terrence	Sejnowski	Biology	8/4/2006	6/30/2013

AFFILIATED FACULTY

(48)

First Name	Last Name	Home Department	Affiliation Date	End Date
Henry	Abarbanel	Physics	7/1/2001	6/30/2008
Thomas	Albright	Salk Institute for Biol. Studies	7/1/2001	
William	Bechtel	Philosophy	7/1/2001	
Rik	Belew	Cognitive Science	7/1/2001	
Ursula	Bellugi	Psychology / Salk	7/1/2001	
Edward	Callaway	Salk	7/1/2008	
Richard	Carson	Economics	7/1/2001	6/30/2008
Gert	Cauwenbergh	Biology	7/1/2005	
Gert	Cauwenberghs	Neurobiology		
Andrea	Chiba	Cognitive Science		
E. J.	Chichilnisky	Salk	7/1/2008	
Patricia	Churchland	Philosophy	7/1/2000	6/30/2009
Paul	Churchland	Philosophy	7/1/2001	
Garrison	Cottrell	Computer Science	7/1/2000	6/30/2009
Anders	Dale	Neurosciences	7/1/2005	
Virginia	DeSa	Cognitive Science	7/1/2001	
Sascha	du Lac	Salk	7/1/2008	
Jeffrey	Elman	Cognitive Science	7/1/2000	6/30/2009

Shaya	Fainman	Electrical & Computer Engineering	7/1/2001	6/30/2008
Michael	Goldbaum	Ophthalmology	7/1/2008	
Philip	Groves	Psychiatry	7/1/2001	6/30/2008
Allen	Gruber	SCCN	7/1/2008	
Deborah	Harrington	Radiology	7/1/2008	
Robert	Hecht-Nielsen	ECE	7/1/2008	
Harvey	Karten	Neuroscience	7/1/2000	6/30/2009
David	Kirsh	Cognitive Science	7/1/2001	
David	Kleinfeld	Physics	7/1/2008	
Richard	Krauzlis	Salk	7/1/2008	
William	Kristan	Neurosciences	7/1/2001	
Paul	Kube	Computer Science	7/1/2001	6/30/2008
Marta	Kutas	Cognitive Science	7/1/2001	6/30/2009
Donald	Macleod	Psychology	7/1/2001	
Harold	Pashler	Psychology	7/1/2001	
V. S.	Ramachandran	Psychology	7/1/2008	
John	Reynolds	Salk	7/1/2008	
Terrence	Sejnowski	Biology / Salk	7/1/2001	
Terrence	Sejnowski	Biology		
Terrence	Sejnowski	Biology		
Terrence	Sejnowski	Biology		
Tanya	Sharpee	Salk	7/1/2008	
Gabriel	Silva	Bioengineering / Ophthalmology	7/1/2008	
Larry	Squire	Psychology	7/1/2001	
Jerome	Swartz			
Emo	Todorov	Cognitive Science	7/1/2008	
Mohan	Trivedi	Electrical & Computer Eng.	7/1/2001	
Halbert	White	Economics	7/1/2001	6/30/2008
Ruth	Williams	Mathematics	7/1/2001	
David	Zipser	Cognitive Science	7/1/2001	

RESEARCHERS

(17)

First Name	Last Name	Payroll Title	Appt. Date	End Date
Marian	Bartlett	Associate Research Scientist (Non-Business/Engineering)	7/1/2006	06/30/2010
Roger	Bingham	Associate Specialist	07/01/2007	06/30/2010
Seunghyon	Choe	Research Scientist (Non-Business/Engineering)	02/01/2007	06/30/2012

Leanne	Chukoskie	Assistant Project Scientist (Non-Business/Engineering)	02/01/2009	06/30/2010
Arnaud	Delorme	Assistant Project Scientist (Non-Business/Engineering)	7/1/2004	06/30/2010
Jeng-Ren	Duann	Assistant Project Scientist (Non-Business/Engineering)	9/1/2004	08/08/2009
Klaus	Gramann	Assistant Project Scientist (Non-Business/Engineering)	7/1/2007	6/30/2011
Ralph	Greenspan	Research Scientist (Non-Business/Engineering)	08/01/2008	06/30/2011
Tzyy-Ping	Jung	Research Scientist (Non-Business/Engineering)	11/1/2002	06/30/2011
Claudia	Lainscsek	Assistant Project Scientist (Non-Business/Engineering)	7/1/2004	06/30/2010
Gwendolen	Littlewort	Assistant Project Scientist (Non-Business/Engineering)	7/1/2004	6/30/2011
Scott	Makeig	Research Scientist (Non-Business/Engineering)	07/01/2003	6/30/2012
Javier	Movellan	Research Scientist (Non-Business/Engineering)	11/01/2007	06/30/2010
Julie	Onton	Assistant Project Scientist (Non-Business/Engineering)	08/01/2006	06/30/2010
Howard	Poizner	Research Scientist (Non-Business/Engineering)	03/15/2005	06/30/2011
Peter	Rowat	Associate Project Scientist (Non-Business/Engineering)	11/1/2005	6/30/2011
Ryuichi	Yamada	Assistant Project Scientist (Non-Business/Engineering)	02/01/2009	06/30/2010

POST DOCS

(15)

First Name	Last Name	Payroll Title	Appt. Date	End Date
Zeynep	Akalin Acar	Postdoctoral Scholar-Employee	10/15/2008	10/14/2009
Maxime	Bonjean	Postdoctoral Scholar-Employee	09/01/2008	08/31/2009
Timothy	Brown	Postdoctoral Scholar-Fellow	07/01/2008	06/30/2009
John	Curtis	Postdoctoral Scholar-Fellow	08/18/2008	08/17/2009
Inna	Fishman	Postdoctoral Scholar-Fellow	09/01/2008	08/31/2009
Ruey-Song	Huang	Postdoctoral Scholar-Employee	07/01/2008	06/30/2009
Brock	Kirwan	Postdoctoral Scholar-Fellow	10/1/2007	9/30/2008
Tanya	Kralijic	Postdoctoral Scholar-Fellow	10/01/2007	09/30/2008
Dongpyo	Lee	Postdoctoral Scholar-Employee	10/01/2008	09/30/2009
Xiaoyan	Li	Postdoctoral Scholar-Employee	07/14/2008	07/31/2009
Jason	Palmer	Postdoctoral Scholar-Employee	12/01/2008	11/30/2009

David	Peterson	Postdoctoral Scholar-Employee	08/05/2008	08/04/2009
Michael	Pitts	Postdoctoral Scholar-Fellow	07/01/2008	06/30/2009
Yijun	Wang	Postdoctoral Scholar-Employee	02/19/2008	07/31/2009
Ying	Wu	Postdoctoral Scholar-Employee	10/01/2008	09/30/2009

STAFF

(34)

First Name	Last Name	Payroll Title	Start Date	End Date
Nima	Bigdely-Shamlo	Programmer/Analyst III	10/1/2005	999999
Robert	Buffington	Programmer/Analyst III	5/1/2004	999999
Sheau-Yen	Chen	Programmer/Analyst III	04/01/2009	999999
Mitchell	Datlow	Writer, Sr	04/01/2008	08/05/2009
Cristina	Domnisoru	Technician, Development, III	09/17/2008	06/03/2009
Micah	Eckhardt	Staff Research Assoc I	7/11/2006	07/07/2008
M. Luisa	Flores	Admin. Specialist	05/03/2005	999999
Lucas	Gilbert	Programmer/Analyst III	04/01/2009	08/31/2009
Carolan	Gladden	Admin. Specialist	10/29/2008	999999
Glynnis	Hubbard	Staff Research Assoc II	06/20/2007	12/31/2009
Carol	Hudson	Analyst, Administrative	06/02/2008	999999
Kelly	Hudson	_____Assistant III	08/14/2008	999999
Grace	Kang	Staff Research Assoc II	10/18/2007	07/31/2008
Andrew	Kovacevic	Admin. Specialist	03/01/2008	999999
Ryan	Low	Staff Research Assoc I	9/29/2006	08/31/2009
Scott	Makeig	Director	07/01/2007	999999
Emelia	Marapao	Analyst, Administrative	08/01/2006	999999
Shelley	Marquez	Management Servs Officer III	9/1/2005	999999
Rhonda	McCoy	Analyst, Administrative	02/19/2008	999999
Kristen	Michener	_____Assistant III	1/1/2006	999999
Luis	Palacios	Programmer/Analyst II	08/01/2008	999999
Margaret	Paulson	Admin. Specialist	06/01/2006	999999
Linda	Phan	Staff Research Assoc II	03/12/2009	999999
Angelica	Rodriguez	Laboratory Asst I	04/21/2009	999999
Andrew	Salamon	Programmer/Analyst II	3/20/2006	999999
Wayne	Schroeder	Programmer/Analyst Iv	04/01/2009	999999
Kathryn	Shanks	Staff Research Assoc I	03/02/2009	04/26/2009
Julie	Sullivan	_____Assistant III	10/13/2006	999999
Paul	Tooby	Manager	04/01/2009	999999
Elke	Van Erp	Laboratory Asst II	05/15/2008	08/14/2008
Andrey	Vankov	Engineer, Development, Sr	5/1/2006	999999
Esra	Vural	Staff Research Assoc II	05/15/2008	08/15/2008

Michael	Wan	Specialist	04/01/2009	999999
Bing	Zhu	Programmer/Analyst III	04/01/2009	999999

STUDENTS

(32)

First Name	Last Name	Home Department	Status
Chan Yau	Ao	I N C	Undergraduate
Denise	Aquino	I N C	Undergraduate
Eunice	Aquino	HSNG/DNG HOSP	Undergraduate
Jacob	Bergsma	I N C	Undergraduate
Nicholas	Butko	Cog Sci	Graduate Student Paid
Lucy	Dang	I N C	Undergraduate
Nandini	Datta	I N C	Undergraduate
Eva	Eisend	Institute for Neural Computation	Graduate Student Volunteer
Matti	Gartner	Institute for Neural Computation	Graduate Student Volunteer
Jiucang	Hao	Physics	Graduate Student Paid
Sabine	Jatzev	Institute for Neural Comptation	Undergraduate Volunteer
Christian	Kothe	Institute for Neural Computation	Graduate Student Volunteer
In Tae	Lee	E C E	Graduate Student Paid
Matthew	Leonard	Cog Sci	Graduate Student Paid
Yuan-Pin	Lin	Institute for Neural Computation	Graduate Student Volunteer
Clarissa	Lock	I N C	Undergraduate
James	Marshel	Salk	Graduate Student Paid
Kian Win	Ong	C S E	Undergraduate
Yilian	Pei	I N C	Undergraduate
Duangmanee	Putthividhya	E C E	Graduate Student Paid
Lara	Rangel	Neuroscience	Graduate Student Paid

Nicholas	Rosseinsky	BIO	Graduate Student Paid
Paul	Ruvolo	C S E	Graduate Student Paid
Devapratim	Sarma	I N C	Undergraduate
Nathaniel	Smith	Cog Sci	Graduate Student Paid
Anita	Vishwakarma	I N C	Undergraduate
Sebastian	Welke	Institute for Neural Computation	Graduate Student Volunteer
Jacob	Whitehill	C S E	Graduate Student Paid
Ting-Fan	Wu	C S E	Graduate Student Paid
Theodore	Yu	E C E	Undergraduate
Thornsten	Zander	Institute for Neural Computation	Graduate Student Volunteer
Dayou	Zhou	C S E	Undergraduate

VISITORS

(26)

First Name	Last Name	Home Institution	Begin Date	End Date
Zeynep	Akalin Acar	Middle East Tech U.	10/15/2007	11/05/2011
Doris	Alvarez	Science Network	04/20/2009	04/19/2010
Tanya	Baker	Salk Institute	11/01/2007	11/30/2009
Maxim	Bazhenov	UC Riverside	09/01/2008	08/31/2009
Maxime	Bonjean	U. of Liege	09/15/2007	09/14/2012
Arnaud	Delorme	Centre de Recherche Cerveau and Cognition, Toulouse, France	11/13/2005	11/12/2009
Dan	Ferris	U. of Michigan	01/01/2008	08/31/2008
Klaus	Gramann	Ludwig-Maximilians U.	03/20/2007	03/19/2012
Gil Jin	Jang	KAIST	09/01/2007	08/31/2008
Sang Hun	Kim	Choi, Mun-kee Electronic & Telecommuting Research Inst.	12/01/2007	11/30/2008
Hyun-Sook	Lee	Sangji University	03/01/2009	02/28/2010
Xiaoyan	Li	INC	07/14/2008	07/31/2009
Fei	Long	U. of Science & Tech of China	04/30/2009	04/29/2010
Chung-Chin	Lu	National Tsing Hua U.	09/04/2007	08/19/2008
Samat	Moldakarimov	Salk Institute	02/19/2008	02/19/2009
Christo	Pantev	U. of Munster	06/01/2009	07/31/2009

Steve	Prescott	The Salk Institute	09/15/2005	09/01/2008
Arcot	Rajasekar	U. of North Carolina @ Chapel Hill	04/01/2009	07/31/2009
Joseph	Snider	Salk Institute	06/30/2009	12/31/2009
George	Turi	Max Planck Inst. for Brain Research	11/20/2008	02/20/2009
Elke	Van Erp	Universiteit van Amsterdam	09/01/2005	09/30/2008
Margo	Virnes	U. of Joensnn	09/01/2007	06/30/2008
Dejan	Vucinic	MIT	11/01/2008	10/31/2009
Esra	Vural	Sabanci University	06/01/2006	05/31/2010
Yijun	Wang	INC	02/01/2008	01/31/2010
Ryuichi	Yamada	School of Integrated Biology	02/01/2009	06/30/2010

PPS Head Count

	2009
Career Staff	16
Graduate Students	11
Other - In Residence	0
Other Academics	0
Postdoc Fellow/Postdoc Grad Res	10
Regular Faculty	0
Researchers	11
TA/Reader/Tutor	0
Temp Faculty	0
Temporary Staff	18
Total	**66**

FACILITIES

	2009
Administrative Office	3,473
Central Computer / Telecomm	76
Conference Room	250
Office Service	651
Research Lab / Studio Service	3,338
Research Laboratory / Studio	6,654
Research Office	1,851
Totals (assignable sq. ft.)	**16,293**

INCOME

Balance Forward

	2009	Total
418717 —*Institute For Neural Computation*	2,366,321	**2,366,321**
438717 —*Institute For Neural Computation*	(13)	**(13)**
788717 —*Student Aid-Inst Neural Computation*	313,215	**313,215**
Total	**2,679,523**	**$2,679,523**

Permanent Budget

	2009	Total
418717 —*Institute For Neural Computation*	103,298	**103,298**
Total	**103,298**	**$103,298**

Contract and Grant Allocations - Unit Code: 208

Sponsor Category Totals - Unit Code: 208

	Transactions	Direct	Indirect	Total
Higher Education	5	805,249	419,266	**1,224,515**
Federal	20	6,862,381	1,475,872	**8,338,253**
Foundation	1	145,000	0	**145,000**
Interest Group	0	0	0	**0**
UC Campus	0	0	0	**0**
Other Government	0	0	0	**0**
Business	0	0	0	**0**
Other Charitable	0	0	0	**0**
State	0	0	0	**0**
DOE Labs	0	0	0	**0**
Totals	**26**	**7,812,630**	**1,895,138**	**$ 9,707,768**

User Reported Income

	418717	434997	438717	788717	Total
Abraxis BioScienc, Inc.	184,473	0	0	0	**184,473**
East Bay Community Fndn.	20,000	0	0	0	**20,000**
Fellowships	0	0	0	0	**0**
Gifts	0	0	0	0	**0**
Other income	0	0	0	0	**0**
Qualcomm	1,000	0	0	0	**1,000**
Rancho Sante Fe Fndn.	1,000	0	0	0	**1,000**
Service Agreements	0	0	0	0	**0**
Swartz Fdn	816,670	0	0	0	**816,670**
Totals	**1,023,143**	**0**	**0**	**0**	**$ 1,023,143**

EXPENSE

Expense Summary

	418717	788717	Total
Academic Salaries	641,232	0	**641,232**
Benefits	350,462	7,613	**358,075**
Equipment	913,420	0	**913,420**
General Assistance	39,575	0	**39,575**
Indirect Costs	559,153	10,736	**569,889**
Recharge Income	0	0	**0**
Staff Salaries	514,108	0	**514,108**
Supplies	300,419	155,748	**456,167**
Transfers In	40,254	0	**40,254**
Travel	61,459	0	**61,459**
Totals	**3,420,081**	**174,098**	**$ 3,594,179**

Expense By Program

	2009	Total
Core Account Research	7,239,537	**7,239,537**
General Instruction	0.48	**0.48**
Grad-Fees	49,686	**49,686**
Grad-Stipends	293,362	**293,362**
Uc Discovery/Duann/Itl06-10160	(39,628)	**(39,628)**
Uc Discovery/Movellan Dig05-10202	943	**943**

Totals	**7,543,900**	**$7,543,900**

PUBLICATIONS

JOURNALS (84)

All Peer-Reviewed:

Ahmadi, M.E., Brown, T.T., Kuperman, J.M., Roddey, J.C., White, N.S., Shankaranarayanan, A., Han, E., Rettmann, D., & Dale, A.M. (2009) 3D Prospective Motion Correction System (PROMO) in Pediatric Population. International Society for Magnetic Resonance in Medicine. (in press).

Akalin Acar, Z., Makeig, S. (2008, August). Neuroelectromagnetic forward modeling toolbox. Proceedings of IEEE EMBC, Vancouver, Canada.

Ataseven,Y., Akalin Acar, Z., Acar, C.E., Gencer, N.G. (2008). Parallel implementation of the accelerated BEM approach for EMSI of the human brain. Med. & Biol. Eng. & Comp.

Bartlett, M. Littlewort, G. Vural, E., Lee, K., Cetin, M., Ercil, A., & Movellan, M. (2008). Data mining spontaneous facial behavior with automatic expression coding. Lecture Notes in Computer Science 5042, p. 1-21.

Becker, C., Gramann, K., Mueller, H.J., Elliott, M.A. (2009) Electrophysiological correlates of flicker-induced color hallucinations. Consciousness Cognition.

Behrens, M.M. & Sejnowski, T.J. Does Schizophrenia Arise from Oxidative Dysregulation of Parvalbumin-Interneurons in the Developing Cortex?, Neuropharmacology, (in press).

Bigdely Shamlo , N., Ramirez, R., Vankov, A., & Makeig, S. (revision submitted). Real-time brain activity-based identification of targets during rapid serial visual presentation. IEEE Transactions on Neural Systems and Rehabilitation Engineering.

Bigdely-Shamlo, N., Vankov, A., Ramirez, R.R., Makeig, S. (2008) Brain activity-based image classification from rapid serial visual presentation. IEEE Trans Neural Syst Rehabil Eng.

Bjerre, V., Onton, J., Makeig, S., & Christofferson, G. (in revision). Effects of human working memory load on frontal and posterior midline theta activities in EEG-recordings: changes during normal aging. NeuroImage.

Butko, N. & Movellan, J.R. (2008). I-POMDP: An Infomax Model of Eye Movement, Proceedings of the 2008 IEEE International Conference on Development and Learning (ICDL), August 9-12.

Butko, N.J., Zhang, L. Cottrell, G.W., & Movellan, J.R. (2008) Visual saliency model for robot cameras. In International Conference on Robotics and Automation (ICRA) 2008.

Chan, J., Leung, H., & Poizner, H., Correlation among Joint Motions Allows Classification of Parkinsonian versus Normal 3D Reaching Movements, IEEE Transactions on Neural Systems and Rehabilitation Engineering, June 2, 2009 [E-pub ahead of print].

Chen, E., Stiefel, K.M., Sejnowski, T.J., & Bullock, T.H. Model of traveling waves in a coral nerve network, Journal of Comparative Physiology A, 194(2):195-200 (2008).

Cockburn, J., Bartlett, M., Tanaka, J. Movellan, J., & Schultz, R. (2008). SmileMaze: A tutoring system in real-time facial expression perception and production in children with Autism Spectrum Disorder, Proceedings from the IEEE International Conference on Automatic Face & Gesture Recognition (peer-reviewed conference proceeding), 978-986.

Conner, J.M., Franks, K.M., Titterness, A.K., Merrill, D.A., Christie, B.R., Sejnowski, T.J., & Tuszynski, M.H. NGF is Essential for Hippocampal Plasticity and Learning, J. Neuroscience, (in press).

Curtis, J.C. & Kleinfeld, D. (2009). Phase-to-rate transformations encode touch in cortical neurons of a scanning sensorimotor system. Nature Neuroscience (in press).

Delorme A., Sejnowski T.J., & Makeig S. (2008). Improved rejection of artifacts from EEG data using high-order statistics and independent component analysis. NeuroImage,

Destexhe, A., Sejnowski, T. J., The Wilson-Cowan Model, 36 Years Later, Biological Cybernetics, (in press).

Englitz, B., Stiefel, K.M., & Sejnowski, T.J., Irregular firing of isolated cortical interneurons in vitro driven by intrinsic stochastic mechanisms, Neural Computation, 20(1): 44-64 (2008).

Finelli, L.A., Haney, S., Bazhenov, M., Stopfer, M., & Sejnowski, T.J., Synaptic learning rules and sparse coding in a model sensory system, PLoS Comput Biol, 4 (4): e1000062. doi:10.1371/journal.pcbi.1000062, (2008).

Fishman, I., Goldman, M., & Donchin, E. (2008). P300 as a neurophysiological probe of alcohol expectancy processes. Experimental and Clinical Psychopharmacology, 16 (4), 341-356. PMID: 18729689

Frohlich, F., Bazhenov, M., & Sejnowski, T.J., Pathological effect of homeostatic synaptic scaling on network dynamics in diseases of the cortex. Journal of Neuroscience, 28(7): 1709-1920, (2008).

Frohlich, F., Bazhenov, M., Iragui-Madoz, V., & Sejnowski, T.J. Potassium dynamics in the epileptic cortex: New insights on an old topic. The Neuroscientist 14 (5):422?433, (2008).

Gramann, K., el Sharkawy, J., Deubel, H. (in press) Eye-movements during navigation in a virtual tunnel. International Journal of Neuroscience.

Greenwood, P. & Rowat, P. (in progress) Distribution of spike sequence length and inter-spike-intervals of the Morris-Lecar neuron.

Groppe, D., Makeig, S., & Kutas, M. (2009). Identifying Reliable Independent Components via Split-Half Comparisons (0.8MB pdf) NeuroImage, http://dx.doi.org/10.1016/j.neuroimage.2008.12.038

Grosse-Wentrup, M., Liefhold, C., Gramann, K., Buss, M. (2009). Beamforming in non-invasive Brain-Computer Interfaces. IEEE Transactions on Biomedical Engineering.

Hammon, P.S., Makeig, S., Poizner, H., Todorov, E., & de Sa, V. (2008). Extracting trajectories and target endpoints from human EEG during a reaching task, IEEE Signal Processing, 25, 69-77.

Hao, J., Attias, H., Nagarajan, S., Lee, T., & Sejnowski, T.J. Speech Enhancement, Gain, and Noise Spectrum Adaptation Using Approximate Bayesian Estimation, IEEE Transactions on Audio, speech and Language Processing 17 (1): 24-37 (2009).

Hao, J., Lee, T.W., & Sejnowski, T.J. Speech Enhancement using Gaussian Scale Mixture Models, IEEE Transactions on Audio, Speech and Language Processing, (in press).

Ho, T.J., Duann, J.R., Chen, C.M., Chen, J.H., Shen, W.C., Lu, T.W., et al. (2008). Carryover effects alter FMRI statistical analysis in an acupuncture study. The American Journal of Chinese Medicine.

Huang, R.-S., Jung, T.-P., Delorme, A., & Makeig, S. (2008). Tonic and phasic electroencephalographic dynamics during continuous compensatory tracking. Neuroimage.

Huang, R.-S., Jung, T.-P., Delorme, A., & Makeig, S. (2008). The engaging and disengaging brain: Event-related electroencephalographic dynamics in a continuous compensatory tracking task. NeuroImage.

Kanan, C., Tong, M.H., Zhang, L., & Cottrell, G.W. (accepted). SUN: Top-down saliency using natural statistics. Visual Cognition: Special issue on eye guidance in natural scenes.

Keller, D.X., Franks, K.M., Bartol, T.M., & Sejnowski, T.J. Calmodulin activation by calcium transients in the postsynaptic density of dendritic spines, PLoS ONE 3(4): e2045. doi:10.1371/. PMCID: PMC2312328, (2008).

Kerr, R.A., Bartol, T.M., Kaminsky, B., Dittrich, M., Chang, J.-C. J., Baden, S., Sejnowski, T.J., & Stiles, J.R. Fast Monte Carlo simulation methods for biological reaction-diffusion systems in solution and on surfaces, SIAM Journal on Scientific Computing, 30(6) 3126-3149 (2008).

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Huang, R.S., Jung, T-P., Delorme, A. & Makeig, S. (2009).Tonic and Phasic Brain Dynamics during Responses to Simulated Driving Challenges, 15th Annual Meeting, Organization of Human Brain Mapping, Neuroimage, 47, sup 1, 481 SA-AM, p S103, Poster, June 18th-22nd.

Jung, TP. Course Instructor, Course topic: Independent Component Analysis and Beyond: Blind Signal Processing and its Applications. Annual Conference of SPIE Defense, Security + Sensing, Orl, FL, April 15, 2009.

Jung, T.P. (2009, April 14) Session 6: ICA Applications I. Session Co-Chair at Annual Conference of SPIE Defense, Security + Sensing, Orlando, FL.

Jung, T.P. Session chair, Session 7: ICA Applications II: Neural Network Learning, Annual Conference of SPIE Defense, Security + Sensing, Orlando, FL, April 14, 2009.

Jung,T-P. Keynote speaker, Neuroengineering Workshop, National Chiao Tung University, Hsinchu, Taiwan, May 15, 2009.

Jung, T.P. Invited Talk, Cognition Science Learning Lab, Institute for Education, National Chiao Tung University, May 11, 2009.

Lainscek, C., Rowat, P., Schettino, L., Song, D.D., & Poizner, H. Nonlinear temporal dynamics of repetitive hand movements in Parkinson's disease: Improved results using genetic search of nonlinear DDE models. Abstract 639.22, Society for Neuroscience Annual Meeting 2008, Washington DC.

Liefhold, C., Gramann, K., & Buss, M. Beamforming in Noninvasive Brain?Computer Interfaces. IEEE Transactions on Biomedical Engineering, Vol. 56, No. 4, April 2009 1209 Moritz Grosse-Wentrup*, Member, IEEE.

Low, P.S., Barton, S.C., Landreth, R., & Sejnowski, T.J. R.E.M. Revealed, Society for Neuroscience Abstracts, (2008).

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EVENTS

SEMINARS (8)

Title	Date	Presenter	Location
INC Seminar	2008-08-21	Paul Verschure	CSB 280
INC/Swartz Center Seminar	2008-08-25	Katherine Holzbaur	CSB 180
INC/TDLC Seminar	2008-10-28	John Hershey	CSE 1202
INC/Embodied Cognition Lab and TDLC Seminard	2008-10-29	Alison Pease, PhD	CSB 003
INC and TDLC Seminar	2009-04-27	Peter Fox, M.D.	SDSC E - B145E
Cognitive Neuroscience Spring Retreat	2009-05-02	Irving Biederman, PhD	Salk Institute Trustees Room
Joint CalIT2 - INC Biological Physical Seminar	2009-05-22	Blaise Aguera y Arcas	CalIT2 Auditorium, Atkinson Hall
Institute for Neural Computation Seminar	2009-07-20	Gerwin Schalk	CSB 280

LECTURES (3)

Title	Date	Presenter	Location
Lecture	2008-07-24	Peter Robinson	CSB 180
INC and UCSD Dept of Bioengineering	2008-08-12	Shantanu Chakrabartty	Powell-Focht Bioengineering Hall
H. Paul Rockwood Memorial Lectureship	2009-03-20	Josh Bongard	

CONFERENCES (1)

Title	Date	Presenter	Location
16th Joint Symposium on Neural Computation	2009-05-16	Horace Barlow and many others	USC

OTHER (1)

Title	Date	Presenter	Location
The Neuron Simulation Environment	2009-06-20	various	INC

NARRATIVE

Director's Statement

MISSION

The mission of the Institute for Neural Computation (INC) is to bring together the diverse

INC ANNUAL REPORT 2009

MISSION

The mission of the Institute for Neural Computation (INC) is to bring together the diverse research community in the basic sciences, medical, and engineering disciplines at UC San Diego in advancing and promoting a new science of computation and learning. This science is based on the multiscale, parallel, and highly adaptive architectures found in biological neural systems. INC is committed to worldwide leadership in its research and to work with industrial partners and the broader community in applying research advances to the benefit of society.

Projects include designing and implementing autonomous artificial neural systems interacting intelligently with humans and with complex environments, developing computational neural and brain-machine interfaces to assist in remediation of debilitating diseases of the human nervous system, studying distributed brain dynamics supporting human behavior and agency, and developing the Integrated Rule Oriented Data System (iRODS) for large-scale data sharing and preservation in collaborative research.

DIRECTORS' STATEMENT

Entering its 20th year of existence at UC San Diego, INC is more vital than ever, propelled by a range of visionary approaches in the service of knowledge and mankind. These encompass computational neuroscience, neural modeling, machine intelligence, brain-machine interfaces neuroengineering, and translational applications in biomedicine.

Fiscal growth of INC mirrors the breadth, depth and vitality of the Institute:

$ 4,000,000	Research Expenditures	2007-08
$ 7.500,000	Research Expenditures	2008-09
$13,000,000	To be Allocated	2009-10

INC recently relocated core operations to the entire first (B1) floor of the new San Diego Super Computer Center (SDSC) East Expansion building, housing the Swartz Center for Computational Neuroscience, as well as the Temporal Dynamics of Learning Mobile Brain Imaging facilities. In addition, a lively new logo was recently launched, as well as a re-named, re-tooled INC quarterly newsletter, the inc*ubator.*

INC also continues to forge new connections with other UC San Diego research groups, as well as with local industry, government labs, and the clinical sector.

RESEARCH ON CENTER STAGE

Over the past year INC has doubled its research operations to more than $5 million in funds brought in by an exceptionally dynamic team of investigators, including more than $1 million in new equipment funds for mobile brain imaging.

Motion Capture Facility/Brain Dynamics Facility

The facility provides a range of devices for tracking behavior, including hand movements, eye movements, full body movements, facial expressions and inter-personal interactions, as well as presenting stimuli that are tightly coupled with the observed behaviors (e.g. via Virtual Reality or mechanically via robotic devices). The goal is tools for researchers to manipulate time and timing and to investigate its role in learning and in the development of adaptive behavior. The facility features state-of-the-art equipment for marker-based motion capture, high-speed video recording, eye tracking, hand tracking, and muscle recording.

The facility is integrated with the Brain Dynamics Facility through high-density EEG recording system for measuring brain dynamics. Complementing the hardware, the Motion Capture Facility provides a suite of software tools for data analysis and simulation, including a system for automated recognition of facial expressions, hand gestures and gaze directions; a system for probabilistic inference of joint angle trajectories, skeletal parameters and marker attachments from noisy data; and a modeling environment for simulation and visualization of musculo-skeletal dynamics.

Machine Perception Lab

The goal of the MPLab is to gain insights into how the brain works by developing embodied systems that solve problems similar to those encountered by the brain. The focus is on systems that perceive and interact with humans in real time using natural communication channels (e.g., visual, auditory, and tactile information). To this effect perceptual primitives are being developed to detect and track human faces and to recognize facial expressions. Also being developed are probabilistic models for integrating multiple sensory modalities and actions. Developing such systems requires a multidisciplinary approach that combines mathematical modeling, machine learning techniques, computational modeling of brain function, and behavioral experiments. Applications include personal robots, automatic tutoring systems, and automatic assessment of affective disorders.

Motion Capture and Brain Imaging Studies

The goal of **Howard Poizner's** lab is to better understand the neural bases of human motor control. The approach is to analyze the nature of the breakdown in motor control in patients with selective failure of specific motor (or sensory) systems of the brain, such as occurs in Parkinson's disease, cerebellar ataxia, or limb deafferentation. Toward this end, novel methods have been developed of imaging and graphic analysis of spatiotemporal patterns inherent in digital records of movement trajectories. One domain of studies is Parkinson's disease. One hypothesis being evaluated is that a key function of the basal ganglia which is impaired in Parkinson's disease is support for the recoding and integration of proprioceptive signals with other sensory and motor signals in order to enable accurate movements. Now being investigated is the haptic sensitivity of Parkinson's patients, how Parkinson's patients reach to targets presented in 3D space under various conditions of visual feedback, as well as using 3D immersive virtual environments to investigate how Parkinson's patients learn to adapt their movements in altered sensorimotor environments.

Movement and reward-based learning. Using the Motion Capture/Brain Dynamics Facility to combine high-resolution EEG analysis with fine-grained temporal analysis of motor performance in a reward-based learning task, this task was closely modeled on those used to elucidate dopamine's role in signaling expected reward and decisions for actions in animal studies. Here subjects learned to make decisions under uncertainty. The decision itself was a movement reaching to one of two stimuli with different probabilities of payout of reward presented on a touch screen. EEG monitoring was used to examine the correlation between cortical activity and decision processes and to determine those changes in dynamic cortical activity relevant to learning of the task.

The team examined the ability of subjects to learn an association between visual stimuli and reward probability, and midway through the task session the reward probabilities of the stimuli were reversed. The hypothesis was that Parkinson's Disease (PD) subjects off dopaminergic therapy would be deficient in optimizing strategy and would show specific impairment in learning when reward probabilities are reversed. Seventeen PD subjects off dopaminergic therapy and 15 age-matched controls participated, and the group reports in a manuscript that the PD patients exhibited impaired reward-based learning, particularly when the reward contingencies were reversed. The computational modeling of the subjects' behavior indicated that the patients' ability to adapt to dynamic reward contingencies was contingent upon the weight they attributed to information early in learning.

In addition, 13 young adults were tested while simultaneously recording EEG and limb movement. With these subjects it was found that the trial-by-trial reward prediction error from the computational model was inversely correlated with oscillatory EEG dynamics in the theta and alpha-bands, 300-500 ms post-reward. To the knowledge of the researchers, this is the first report showing a relationship between the internal variables driving rewarded learning and single-trial scalp EEG. Importantly, this effect appeared in independent neural processes with dipoles localized in or near ventromedial prefrontal cortex, an area implicated in decision-making under uncertainty. Further evaluation of the results is underway, in light of traditional ERP measures such as the event-related negativity and the feedback-related negativity.

The group has also begun to investigate the viability of measuring scalp EEG in Parkinson's patients who have had surgery for deep brain stimulation (DBS). Pending the success at isolating the DBS artifact from the EEG, the plan is to investigate how DBS modulates the brain's endogenous and temporally-exquisite oscillatory processes involved in mediating reward-based learning.

EEG brain dynamics during phoneme production and planning – Applications for brain-computer interfaces (BCIs), Virginia de Sa. BCIs aim to aid individuals who do not have adequate motor control to effectively communicate with the outside world. This project investigates whether a non-invasive BCI for speech can be developed based on EEG. Because the EEG signal is removed from the neural signal, powerful signal processing and classification techniques will likely be required. The researchers propose to investigate the EEG dynamics underlying phoneme formation and use sophisticated EEG/BCI signal processing and classification procedures to distinguish different phonemes.

The studies performed over the first few months of this experiment have been focused on discriminating the imagined production of the vowel phonemes /a/, /i/, /u/ and /e/. Subjects were required to imagine the muscle movements that would be involved in producing each vowel, then to actually say the phoneme aloud. Thus far, two subjects have been tested, with exploratory analysis still being performed. Techniques thus far used for analysis involved learned common spatial patterns coupled with linear discriminant analysis. At present the group is still attempting to determine whether it is more advantageous to pursue a system involving imagined muscle movement or semantic properties.

Brain and muscle dynamics of spatial learning, Scott Makeig. Studies of brain dynamics during natural spatial learning are fraught with the problem of motion artifacts in fMRI, PET, and traditional EEG, which prevents the integrated study of spatial learning and movement. To avoid this problem, the newly developed high-density mobile brain imaging modality (MoBI) uses a mobile EEG-recording system coupled with motion capture that can be used to study the brain and muscle dynamics of subjects freely orienting towards object locations in natural 3-D environments. Advanced signal processing of such EEG recordings combined with high-resolution measurements of movements of the head and upper body can describe brain dynamics accompanying active, natural spatial learning. This allows study of the contribution of proprioceptive and vestibular inputs to higher cortical processing during spatial learning and cognition. Initial work will investigate the influence and timing of proprioception and vestibular input on spatial learning. Future experiments will investigate spatial learning in patients with lesions to brain areas known to subserve egocentric and allocentric spatial learning.

A reduction is funds unfortunately reduced the first year scope of development of the soft- and hardware protocols for an initial pilot to developing a general framework. The experimental environment was set up with computers and screens available from SCCN resources and object locations reduced to 4 based on the available screens and PCs. The necessary protocols for integrating 4 monitors with 1 PC were successfully developed and implemented, and the researchers are now able to record EEG and motion capture in combination with the interactive Datariver structure to display objects on 4 different monitors, dependent on the position and head orientation of the subject. In the future the group aims to integrate a rotating platform to extend the protocol to active and passive movements of the subjects, to be able to directly compare spatial learning with and without the contribution of proprioceptive and vestibular input.

Terry Sejnowski

What is the influence of statistical learning on eye movements in human and non-human primates? When searching for a familiar object in a scene, human and non-human primates use their prior experience with the object to guide their search. For example, when searching for a coffee cup, we look on tabletops, not on the ceiling or walls. Such knowledge about where to find different types of information is learned through experience, both implicitly and explicitly, throughout life. As part of this project an eye movement search task was designed, where subjects learn to find an invisible rewarded target whose location varies, in a predictable manner, from trial-to-trial. It was found that typical subjects use reward information as a top-down modifier of image salience to choose the most appropriate places to look on subsequent trials. These behavioral results have launched side-projects in which people with Parkinson's disease and people with autism are studied.

Extending the hidden target search task to those with Parkinson's and those with autism was indicated as both populations have difficulty learning to use past history of reward to guide future search. The results have the potential to shed light on the mechanisms that contribute to impaired performance of a natural task in two debilitating disorders. A proper interpretation of these findings requires further control experiments that assess the degree to which subjects' performance searching a visible target compares with their search for the hidden target. Currently underway are control experiments needed to clarify the interpretation of our data.

In the plans to relate this search behavior to underlying neuronal correlates, the researchers recognized the advantage of rodent species for awake, behaving neurophysiological studies and the potential of future developmental and genetic manipulations. Studies of spike-timing dependent plasticity offer a biophysical correlate of learning in the rat, but bridges must be built across species to make use of this understanding in human learning. To achieve this end, the team is developing experimental paradigms appropriate for the rat that are analogous to the natural search task in humans and monkeys. They have also begun modeling performance in this task using the temporal difference learning class of reinforcement learning models. Although preliminary versions of the model are promising, they aim to refine the model to a point that they can identify model parameters that affect learning and manipulate those parameters explicitly in coordinated experiments and simulations.

On the dynamics of manipulable objects: semantic, perceptual and motor interactions revealed by the hand in flight. The goal of this project is to study the interaction between motor representations of objects and linguistic representations. Part of this project will include the use the Brain Dynamics and Motion Capture Facility to collect a dataset with detailed information on the motor and brain dynamics of grasping and how these dynamics are altered by higher level linguistic representations.

Now developed is a novel experimental method to assess the evocation of specific hand action representations to words, objects, or sentences in real time. This approach requires subjects to carry out speeded reach and grasp actions on an eight-element response apparatus. Each element affords a unique action, and subjects learn to produce a given manual action in response to a visual cue. The influence of an object, word, or sentence (a priming event) is then measured on reach and grasp performance, time-locked to the visual cue, yielding evidence on the nature and time course of the motor representations evoked by the priming event. Using this methodology, the researchers have measured the rapid evocation of F and V grasps in real time to auditory words denoting manipulable objects (timed from word onset), as well as the modulation of these hand action representations by sentence context. Of great interest, V grasps are rapidly suppressed in sentences that refer to the function of the object (e.g. John used the calculator to add the numbers) while F grasps show the same suppression in sentences that refer to volumetric actions (e.g. John lifted the calculator to clear the shelf).

Finally, kinematic analysis has been used to examine the priming effect of the volumetric properties of an object on reaching and grasping. The color of the object is used to cue the action carried out on a response apparatus and we determine how the shape of the object affects the parameters of reaching and grasping. We have recently shown that the structure of an object exerts an effect even on very late components of hand actions, altering parameters close to the end point of the grasp. These results suggest continuous modulation of the hand in flight by contextual influences, and provide important clues on mechanisms of action planning and execution.

Temporal Difference (TD) learning in a top down task.TD learning is a major computational approach to reinforcement learning based on predicting future rewards. TD learning may underlie the temporal sequence learning explored in Initiative 1 and the statistical learning in eye movements being explored in initiative 3. These projects lend themselves to models incorporating TD learning algorithms that can then explain the empirical results from these projects. TD learning occurs on a time scale of seconds to minutes. A theoretical study has shown that spike-time dependent plasticity (STDP) implements TD learning on the time scale of milliseconds to seconds. This suggests a general principle: The goal of learning is make predictions about future states of the world and behavioral outcomes.

As in the previous project, when searching for a familiar object in a scene, human and non-human primate subjects use their prior experience with that object to guide their search. For example, when searching for a coffee cup, we all look on tabletops, not on the ceiling or walls. Such knowledge about where to find different types of information is learned through experience, both implicitly and explicitly, throughout life.
The researchers have designed an eye movement search task where subjects learn to find an invisible rewarded target whose location varies, in a predictable manner, from trial-to-trial. Typical subjects are found to use reward information as a top-down modifier of image salience to choose the most appropriate places to look on subsequent trials. These behavioral results have launched side-projects in which we study people with Parkinson's disease, and people with autism. (This has led to an NIH-funded supplement.)

The extension of the hidden target search task to people with Parkinson's disease and also people with autism indicate that both populations have difficulty learning to use past history of reward to guide future search. These results have the potential to shed light on the mechanisms that contribute to impaired performance of a natural task in two debilitating disorders.

In plans to relate this search behavior to underlying neuronal correlates, the advantage is recognized of rodent species for awake, behaving neurophysiological studies and the potential of future developmental and genetic manipulations. Studies of spike-timing dependent plasticity offer a biophysical correlate of learning in the rat, but bridges must be built across species to make use of this understanding in human learning. To achieve this end, the plan is to develop a behavioral experiment appropriate for the rat, which is analogous to our natural search task in humans and monkeys.

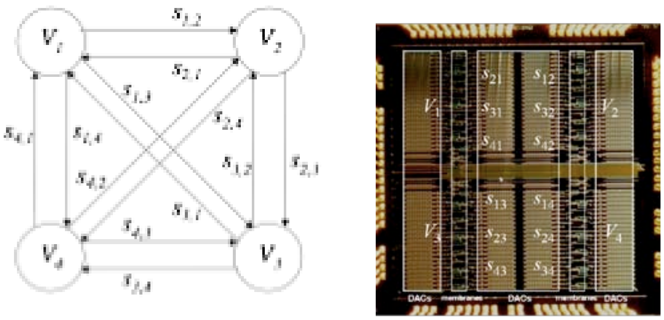
In developing computational models to aid in understanding the data, performance modeling in this task has begun, using reinforcement learning models and models of Bayesian inference in conjunction with Dr. Michael Arnold (Salk), Dr. Michael Mozer (U. Colorado), Nick Butko (UC San Diego) and Jason McInerney (UC San Diego). Rather than a single model, three different approaches are being taken, using a Bayesian framework to develop an optimal model that can be compared with human performance (Arnold), a Markov model that can be fit to the human data (Mozer and Butko), and temporal-difference model based on reinforcement learning (Arnold and McInerney).

Although preliminary versions of each model are promising, the models need further characterization and comparison to explore the parameters that correlate best with learning. The aim is to refine the models in the coming month to a point that model parameters can be identified that affect learning and manipulate those parameters explicitly in coordinated experiments and simulations. The integration of these experiments and models will offer a unique view of natural search performance across several species, providing opportunities to investigate neurophysiological correlates at multiple levels of analysis.

Gert Cauwenberghs

The Integrated Systems Neuro Laboratory, is now on the third floor of the Powell-Focht Bioengineering Hall with research that focuses on cross-cutting advances at the interface between in vivo and in silico neural information processing.

The aims of the group's research are threefold: to empower silicon integrated circuits with adaptive intelligence inspired by information processing in nervous systems; to facilitate advances in computational neuroscience by extending the size and complexity of neuronal networks emulated in silicon to the scale of the human brain; and to interface neurons with silicon--and brains with machines---to study the nervous system in vivo, remediate loss of neural and sensory/motor function, and extend the communication reach of the human mind.

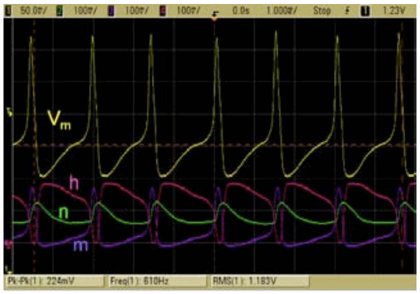


Connectivity diagram (left) and chip micrograph (right) of the recently designed NeuroDyn system. The chip contains 4 Hodgkin-Huxley neurons all fully connected through 12 conductance-based synapses, where all of the parameters defining the conductances, reversal potentials, and voltage-dependence of the channel-kinetics are full programmable. (Yu and Cauwenberghs 2009)

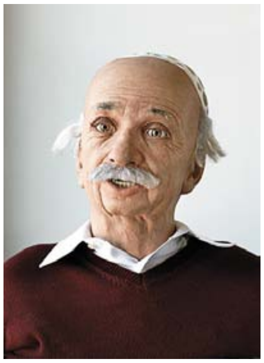
The group's approach combines analysis (neuroscience) and synthesis (neuroengineering) techniques that span bioinstrumentation, neuromorphic engineering, computational and systems neuroscience, and learning and intelligent systems. Their research activities include the design and implementation of very large scale integrated (VLSI) circuits fabricated in silicon and emerging technologies.

The group pioneered the design and implementation of highly energy-efficient, massively parallel microchips that emulate function and structure of adaptive neural circuits in silicon. Embedded mechanisms of synaptic plasticity in these silicon microcircuits model the adaptive intelligence of biological nervous systems interacting with variable and unpredictable environments, and assist in optimizing the energy efficiency and noise robustness of nanoscale circuit components implementing the neural functions. Recently they demonstrated synaptic arrays in silicon for adaptive template-based visual pattern recognition operating at less than a femtojoule of energy per synaptic operation, exceeding the raw computational efficiency of synaptic transmission in the human brain.

A main focus of recent work is on extending integrated sensing and actuation to dynamical interfaces to neural and brain activity. Recent developments include implantable and wireless microelectrode arrays for distributed recording of electrical and chemical neural activity, and biopotential sensor arrays and integrated signal processing for electroencephalogram and electrocorticogram functional brain imaging. These dynamical interfaces between living and artificial nervous systems offer tremendous opportunities for transformative, integrative neuroscience and neuroengineering that are the focus of continued research in collaboration with partners in academia, industry, and the clinical sector.



Oscilloscope trace from the NeuroDyn chip displaying the captured waveforms of the membrane voltage potential (Vm) and gating variables (m, n, and h).



The Einstein Collaboration. This Einstein, a collaboration of designer David Hanson and INC, is an amazing robot head and neck consisting of 27 motors and a bundle of wires coordinated to display lifelike expressions so that its lips purse, brow furrows, eyes widen as though in horror, then scrunch in a grin.

Javier Movellan, psychologist and software pioneer who runs the Machine Perception Lab, develops technology that approximates human senses. For now, Einstein is a research tool to explore how a machine can perceive and react to human facial expressions. But the view is that later it could have many practical applications in entertainment and education, such as alerting robot teachers of the future that their human pupils are daydreaming.

Einstein is part of the larger Project One that focuses on the first year of development. This is a wildly ambitious effort to crack the secrets of human intelligence which involves, as their grant proposal says, "an integrated system...whose sensors and actuators approximate the levels of complexity of human infants."

Some scientists working on social robots, like Movellan and his team, borrow readily from developmental psychology. A machine might acquire skills as a human child does by starting with a few basic tasks and gradually constructing a more sophisticated competence—"bootstrapping," in scientific parlance. In contrast to preprogramming a robot to perform a fixed set of actions, endowing a robot computer with the capacity to acquire skills gradually in response to the environment might produce smarter, more human robots.

This is because programming in incremental fixes for various problems to interact and adapt to a fluid and changing environment becomes frustrating very quickly. "To survive in a social environment, to sustain interaction with people, you can't possibly have everything preprogrammed," Movellan says. Even from the develop-mental viewpoint, the laborious analysis of spoon-fed data—called "supervised learning"—is nothing like the way human babies actually learn. "When you're little nobody points out ten thousand faces and says 'This is happy, this is not happy, this is the left eye, this is the right eye,'" said Nicholas Butko, a PhD student in Movellan's group.

Instead, an "unsupervised learning" process is at the heart of Project One. Project One's robot will be able to move its limbs, train its cameras on "interesting" stimuli and receive readings from sensors through-out its body—which will enable it to borrow more behavior strategies from real infants, such as how to communicate with a caregiver. For example, Project One researchers plan to study human babies playing peek-a-boo and other games with their mothers in a lab. Millisecond by millisecond, the researchers will analyze the babies' movements and reactions. This data will be used to develop theories and eventually programs to engineer similar behaviors in the robot.

The robot baby will be able to touch, grab and shake objects, and the researchers hope that it will be able to "discover" as many as 100 different objects that infants might encounter, from toys to caregivers' hands, and figure out how to manipulate them.

Movellan hopes that the project will "change the way we see human development and bring a more computational bent to it, so we appreciate the problems the infant brain is solving." A more defined understanding of babies' brains might also give rise to new approaches to developmental disorders. "To change the questions that psychologists are asking—that to me is the dream," Movellan adds. "For now it is, how do you get its arm to work, the leg to work? But when we put the pieces together, things will really start to happen."

Dynamics of Facial Expression, Marni Bartlett and Gwen Littlewort. There has been growing recognition that expression dynamics are crucial for understanding internal state and social interaction (e.g. Ambadar et al., in press; Boker et al., in press; Boker et al., submitted; Cohn, 2005). However, there has been very little basic research on facial expression dynamics, since manual coding of dynamics is even more time consuming. Facial expression dynamics contain crucial information that is only just beginning to be tapped as the technology becomes available to measure it. The MPlab has developed a working system named CERT that generates FACS labels from *static* images and provides frame-by-frame expression intensity information that provides a signal for expression dynamics that is ready to be exploited. The goal is to develop methods for characterizing facial expression dynamics from this signal. These methods will be applied to several ongoing research projects in order to (1) characterize facial expression dynamics in development (Reilly), (2) characterize the dynamic coupling of facial behavior in mothers and infants in the development of social learning skills such as shared attention (Deak), (3) characterize facial expression dynamics in children with autism to provide assessment and feedback in the collaborative *Let's Face It!* intervention program for face processing skills with Jim Tanaka at University of Victoria; (4) characterize the dynamics of facial behavior during learning and problem solving tasks (Movellan).

The group approaches the problem using spatiotemporal Gabor wavelets. Similar to optical flow, these are designed to detect movements in a video. However, they estimate the directions of movements within a Gaussian envelope across several frames rather than local pixels in adjacent frames, which effectively prevents the aperture problem commonly seen in optical flow methods. The extracted spatiotemporal features are then learned by a support vector machine. This approach was tested on the well known Cohn-Kanade facial expression dataset and the D006 dataset collected earlier in an NSF project. The results are very promising.

There are several issues in designing the new spatiotemporal Gabor filter method. First of all, extending from spatial to spatiotemporal Gabors dramatically increases the parameter space, which is intractable for brute force search method to find an optimal set of filter bank parameters. We are developing more efficient filter bank selection methods. Secondly, in the literature survey processes, it was found that there is no standard protocol/dataset of assessing the performance for spatiotemporal methods. Some straightforward comparisons between spatial and spatiotemporal methods are in fact unfair to the spatial method. The plan is to address these issues in a publication to help form a standard protocol for such performance comparisons.

In the future the group wants to apply the following promising spatiotemporal methods originally developed for recognizing dynamic textures: (1) Volume Local Binary Pattern (2) Spatiotemporal Haar-features. Hopefully, good comparisons will result of these approaches on the same dataset using the proposed protocol.

Learning to Teach, Javier Movellan. The long term vision of the proposed research is to explore general principles of learning and information transfer in social situations and to use these principles to develop automated perceptive tutoring systems that teach students in a social-like manner. Last year the research showed that facial expression is predictive of two important variables in a teaching context: the student's perception of lecture difficulty and the student's preferred rate of information delivery. Building on this progress is development of a novel framework for autonomous tutoring systems called "Perceptive Teachlets."

Teachlets are defined as everyday-life social teaching episodes responsible for quick transfer of information about key concepts. Teachlets are interactive, closed-loop episodes, i.e., contrary to video clips, they can branch in different ways depending on the perceived cognitive and affective state of the student. The platform, as envisioned here, will include a robot head (in the form of Albert Einstein), automatic expression recognition, and an interactive touch screen to present educational materials. The robot head is currently under construction and was already acquired by the MPLab with ONR/DURIP funds. In the present grant year, the activities will focus on the context of developing a teachlet for teaching simple trigonometric concepts. The ultimate goal of the engineering effort is to improve our scientific understanding of how learning and information transfer occurs in the context of social interaction.

Automated teaching machines have proven to be an elusive goal since the early 1960s. While success stories of such systems do exist, for the most part automated teaching systems have failed to pervade modern education systems. An important reason for this lack of popularity may stem from the unnatural interaction between human pupil and computer teacher that takes place, primarily through a standard keyboard and mouse.

Recent advances in machine perception, including facial expression and head gesture recognition, as well as in realistic humanoid robotics (e.g., the Einstein robot at the Machine Perception Lab) may be changing the playing field. These advances may improve the interface between student and automated teacher significantly and may help to make automated teaching machines a reality. However, a critical question that must be tackled is how to integrate sensor information in order to make optimal teaching decisions with respect to a particular teaching goal. We believe that stochastic optimal control algorithms such as Partially Observable Markov Decision Processes (POMDP's) offer promising solutions to this problem.

Important research progress has been made in the past year, both in the creation of perceptual primitives useful for teaching scenarios and in the study of stochastic optimal control algorithms. We have created a prototype head shake and nod detector based on multivariate logistic regression and Gabor filters of the 3-D pose of the head. This augments nonverbal behavior detection capabilities, which include automatic facial expression recognition. Recognizing nods and shakes is a crucial capability for any automated tutoring system that interacts naturally with humans. Also investigated have been POMDPs for their utility in automated teaching, from both a theoretical and empirical perspective. Being investigated, in terms of theory, are the conditions under which a teaching scenario involving K items to be taught can be broken down into K separate problems, thus vastly reducing the computational expense in determining the optimal teaching policy. A variety of teaching experiments have been empirically performed in simulation mode and shown that the POMDP framework can result in teaching policies that perform superior to a reasonable heuristic policy.

The most recent work models teaching as a cost minimization problem: the cost is time, and the constraint is that the student comprehends the lecture throughout the teaching session. For such a teaching system, it is critical to automatically recognize students' comprehension. To develop such a detector, the researchers are collaborating with a Preuss high school intern, Fadhi Ali, who is annotating video data of real teaching situations for facial expression and comprehension information. This information will be used to create automated detectors of comprehension. Using the POMDP framework, this newly available state information (comprehending/not comprehending) can be used to decide whether to fast-forward, repeat, or continue teaching. This project is a natural extension of previous work on Automatic Facial Expression Recognition for Automated Tutoring Systems.

Perceptual and motor learning in the recognition and production of dynamic facial expressions. Javier Movellan and Marian Bartlett. This project addresses the learning of nonverbal behaviors essential for social functioning. The Computer Expression Recognition Technology (CERT) for real-time analysis of facial expressions developed at UC San Diego is combined with the University of Victoria's *Let's Face It!* software - a computer program shown to effectively improve the face processing abilities of children with Autism Spectral Disorder.

In its present form, the *Let's Face It!* intervention program addresses only recognition of, and not production of, facial expressions. A number of studies have reported atypical facial expression production in ASD (e.g. McIntosh et al., 2006; Rogers et al, 2003; Czapinski & Bryson, 2003). The goal here is to merge the expertise of researchers in order to develop a computer assisted intervention system to enhance the social communication skills of children with Autism Spectrum Disorder (ASD) that focuses on facial expression production. Moreover, training in facial expression production may improve recognition, as motor production and mirroring may be integral to the development of recognition skills. Another advantage of the proposed intervention is that the timing of facial expression displays can be systematically controlled to facilitate the development of recognition skills for dynamic facial expressions.

State-of-the-art computer vision technologies can now be leveraged in the investigation of issues such as the facial expression recognition and production deficits common to children with autism spectrum disorder (ASD). Not only can these technologies assist in quantifying these deficits, they can also be used as part of interventions aimed at reducing deficit severity, as well as contribute to our basic understanding of learning and plasticity in nonverbal behavior.

In this project, automated facial expression recognition using the Computer Expression Recognition toolbox (CERT) is employed in order to provide immediate feedback on facial expression production. CERT measures 37 facial expression dimensions in real-time. Facial production tasks based on CERT feedback are being integrated into the Let's Face It! Training Program (LFI!) (Cockburn et al., 2008).The LFI! system is a training program that has been shown to improve the face processing abilities of children with ASD. By combining the expertise behind these two technologies in disparate disciplines a novel face expertise training prototype has been created: SmileMaze. SmileMaze integrates facial expression production into an intervention program aimed at improving the facial expression recognition and production skills of children with ASD, engaging children with autism, and aiding in learning nonverbal behaviors essential for social functioning. Moreover, training in facial expression production may improve recognition, as perception and production have been shown to be linked in many areas of development.

In SmileMaze, users are required to produce and hold the target expression for varying lengths of time in order to navigate past obstacles located in a maze. The goal of the exercise is to successfully navigate the maze while collecting as many candies as possible. The player controls a pacman-like game piece using the keyboard for navigation (up, down, left, right) and uses facial expressions to move their game piece past obstacles at various points within the maze.

Recent developments include expansion of SmileMaze to additional emotions. Automated detectors for six expressions of basic emotions were developed. A prototype "angry maze" is being piloted. An Emotion Mirror is also under development. Because children with autism are frequently impaired at processing complex dynamic stimuli, a set of simple cartoon animations has been developed for the facial expression mirroring game. On the technical side, development was moved to Adobe Flash, and the RUBIOS operating system, developed at UC San Diego, was enhanced. Images may now be submitted to CERT to get coded so that subjects can choose images of themselves or family members for expression feedback.

According to the "facial feedback hypothesis" making a facial expression can affect one's mood – smiling can make you feel happy, and frowning can make you feel less-so, so one study aimed to demonstrate that creating different facial expressions would induce a subjective experience of that emotion in a systematically measurable way. Results showed that playing the Smile/Angry maze created systematic changes in EMG, GSR and heart rate. Both SmileMaze and AngryMaze increased heart rate and skin conductance, with a larger increase for AngryMaze. The study also includes self-report data (administered via a simple questionnaire program) used to help correlate a participant's physiological measures to their current mood. The questionnaire was given before and after playing SmileMaze and AngryMaze. Following AngryMaze, reported negative affect increased and positive affect decreased. A smaller trend was observed in the opposite direction after playing SmileMaze, with an increase in positive affect and decrease in negative affect.

This year the project to include a social robot platform was expanded. The goal is to enrich the kind of interaction that can occur between children and machine using a social robot. The RUBI robot platform has been successful as a teaching tool for normally developing children at the early childhood education center at UC San Diego. Social robots provide a

promising platform for children with autism because of the potential to be highly engaging and non-threatening for many children with this disorder (Bosseler & Massaro, 2003; Dautenhan et al., 2004; Robins et al., 2004, 2005, 2006). The social robot platform also enables researchers to control specific parameters of social interaction, including temporal parameters including response contingency delay and variability. A highly realistic robot head, “Einstein,” (see the Einstein collaboration) was purchased from Hanson Robotics with ONR equipment funds. The face skin is made of a material called Frubber, that deforms in a skin-like manner contributing to the realism of the robot expressions. The robot was trained through automated feedback from CERT to move its actuators to produce 12 facial actions from the Facial Action Coding system. Six facial expressions of basic emotion were also hand-designed according to the FACS Users’ Guide, as well as a facial expression of confusion. Facial expression mirroring was also developed, in which the robot mimics facial movements of a human participant using automated facial expression recognition with CERT. Mirroring was completed for four basic motions (smile, brow raise, brow furrow, frown).

The RUBI Project, Javier Movellan. Scientific evidence shows that educational practices during the pre-kindergarten years establish the foundation for and have a significant effect on performance in traditional Science, Technology, Engineering, and Mathematics later in life. The goal is to develop and evaluate social robot technologies as teaching aids and enrichment tools for early childhood education. Recent advances in machine learning and machine perception have resulted in perceptual software (e.g., face detection, expression recognition) that works reliably in everyday life conditions. Computers have also become powerful enough to run this software in real time. This opens potential new avenues for robotic tools that interact with children in an affective, social-like manner. Social robots, which basically amount to computers designed to interact naturally with humans, have compelling qualities as an educational medium for early childhood education: They are physical, interactive, and they can engage children individually and personalize educational material. The RUBI project conducts scientific research and technology development activities focused on providing preschool teachers with the best educational technology that contemporary science can offer. The proposed work will be done in close interaction with early childhood education teachers and a leader in the field of infant learning, Dr. John Watson.

The technologies developed as part of this project may help make available forms of early enrichment to populations that need it most and that are at highest risk. Evidence has shown that such early interventions can have measurable effects on later performance in basic skills in Science, Technology, Engineering and Mathematics.

The robot platform allows us to specifically manipulate the temporal parameters of response, and thereby provides a powerful platform on which to study the effects of temporal parameters on social engagement, quality of interaction, and learning. This project has the potential to impact learning on the time scale of years, since early childhood interaction has been shown to affect learning, behavior, and achievement well into adulthood (e.g. Campbell et al., 1995; Ramey et al., 2000).

An important methodological principle in this project was that of design by immersion. This meant that from very early on, the project scientists, engineers, and robot prototypes were immersed in educational settings to discover as soon as possible the problems that had to be solved and the technologies that had to be developed. In this project period the robot was able to function fully autonomously for more than 2 weeks.

Auditory Mood Detection: The original proposal was to do research on automatic detection of classroom moods. Social robots of the type explored in this project need to detect and adapt their behavior to the current social mood. For example, a robot assistant for early childhood education shall behave differently depending on whether the children are crying, laughing, sleeping, or singing songs. The proposed research was performed and a novel algorithm developed for detecting mood from audio. The algorithm was first tested on existing databases of emotion in speech. On this task the system outperformed the previous approaches published in the scientific literature. The group then used the algorithm to detect key classroom moods: crying, playful activities, rest period. The system was trained on the ECEC-MOOD-08 dataset. and achieved a 96 % accuracy level. This was beyond expectations, and resulted in two publications.

Behavioral Studies: The group proposed conducting randomized pre-test/treatment/post-test behavioral studies to evaluate whether the developed technologies had measurable results on academic targets. Two experiments were conducted in July 2008. The first focused on teaching English vocabulary skills, the second on teaching a second language. The first study showed a 10 % improvement on vocabulary skills for the children that had interacted with the robot for a period of 10 days. A preliminary version of this work was presented at the 2009 International Conference on Human Robot Interaction. The results of the second study are currently being analyzed and will become the basis for a submission to a journal publication.

Learning to Teach: The original proposal was to perform research on algorithms to teach social robots and autonomous agents how to be more effective teachers. To pursue the proposed work we first asked teachers to use a setup similar to that used by the social robot and to teach vocabulary skills similar to those taught by the robot. The teacher behaviors were coded with sub-second temporal accuracy using 9 different categories, e.g., teacher gives a hint, teacher presents new object, teacher terminates lesson. A machine learning method, named “apprenticeship learning” was then used to capture into the autonomous teaching robot the same strategies used by the teachers. The results of this work were published at the International Conference on Development and Learning.

Dynamics of Motor Behavior

Peter Rowat’s lab include the following studies:

Channel noise is present in all neurons, generates considerable variability in the timing of neuronal spikes, and has a major effect on the underlying dynamics. There is a good intuitive understanding of the mechanisms underlying these stochastic effects. Now, using the simplest spiking neuron model the researchers have obtained a precise mathematical description of the distribution of inter-spike intervals as a function of the channel noise, which will appear in one publication. Future goals are to extend this result to the Hodgkin-Huxley neuron, to differentiate between channel-noise-dependent and synaptic-noise-dependent spike time variability, and to confirm our model-based results with experimental data.

In humans, both healthy and with Parkinson's disease (PD), there is considerable motor variability in repetitive hand-movements. Using delay differential equations and novel differential-algebraic techniques the group has developed a metric that distinguishes between healthy and PD repetitive hand movements and that grades the severity of PD on a scale that correlates well with the UPDRS clinical scale, as well as finding that when a PD patient is on their meds the associated metric moves towards the values for healthy controls.

Ligand-Receptor Interactions in Computational Neuroscience

Senyon Choe's group continues with efforts of establishing a computational method to analyze biological communications between cells through ligand-receptor interaction. Transforming Growth factor-beta (TGF-beta) family ligands interacting with their cognate cell surface receptors provide a model. TGF-beta have been consistently found to play a role in a variety of cancers. The first goal of the study is to develop a novel algorithm for detecting the presence and estimating the amounts of active and inactive TGF-beta ligands in bodily fluids, with the ultimate goal of discovering new cancer biomarkers.

The main idea behind the strategy is coupling ligand binding events with an accurately measurable physical quantity, such as electric current. As a result, the presence of certain ligands in their active form in the bodily fluids can be quantified by direct measurement of the ionic currents passing through the entire cell surface. The technology would provide a powerful tool for precise measurement of the amount of signaling-active TGFβ superfamily ligands in a sample of bodily fluid. It would also provide a foundation for understanding how these ligands are related to carcinogenesis and thus provides a platform for identifying biomarkers for diagnostic purposes.

Swartz Center for Computational Neuroscience (SCCN)

Investigators at the Swartz Center for Neuroscience (SCCN) observe and model how functional activities in multiple brain areas interact dynamically to support human awareness, interaction, and creativity. Progress was made on the following projects during 2008-2009:

Mobile Brain/Body Imaging (MoBI). Under funding from the Army Research Laboratory (ARL), Scott Makeig and SCCN project scientist Klaus Gramann designed and carried out first experiments on orienting to, pointing to, and walking to objects arrayed in a 3-D laboratory space, and on performing a simple visual response task while standing, walking, and jogging to determine the movement limitations of our recording system. They have found that high-gamma bursts accompany motivated head turns to view or point to a cued object in both neck muscle and motor processes. They have plans for a MoBI laboratory in their new space in the San Diego Supercomputer Center annex, under ONR support and, together with a large group of co-investigators, have submitted a proposal for five-year development of cognitive monitoring of operators working in a complex information environment.

Computational Cognitive Neuroscience, Zeynep Akalin Acar has demonstrated the feasibility of inverse patch basic source imaging using sparse Bayesian learning methods. Scott Makeig and Lawrence Frank of UCSD have proposed to combine high-density EEG modeling with results of Diffusion Tensor Imaging (CTI) of white-matter connections in cortex. Scott Makeig, Julie Onton, and Robert Iocono of the University of Minnesota have proposed to develop individually customized EEG biofeedback protocols with children at risk for alcohol abuse, based on the extensive Minnesota Twins EEG databases.

Multi-resolution Human Electrophysiology. Scott Makeig and SCCN postdoctoral fellow Zeynep Akalin Acar continued to work with collaborator Dr. Gregory Worrell (The Mayo Clinics, Rochester, Minn) on analysis of simultaneously recorded scalp EEG and intracortical grids from epilepsy patients undergoing invasive monitoring for epilepsy surgery planning. They have submitted an NIH proposal to develop electrocortical imaging from intracortical recordings on epileptic patients, including imaging of sulcal sources, something heretofore not possible with current recording methods.

Open Source Software:

Scott Makeig, Arnaud Delorme and UC San Diego collaborator Jeff Grethe have received an NIH grant to build a Human Electrophysiology, Anatomic Data, and Integrated Tools (HeadIT) resource on the distributed BIRN database infrastructure.

Scott Makeig, Arnaud Delorme, Julie Onton, and collaborators have presented three-day EEGLAB workshops at the Centre National de la Recherche Scientifique (CRNS) in Aspet, France and at Indiana University.

Andrey Vankov has begun sharing his ever-expanding DataSuite software including DataRiver and Producer applications for producing interactive experiments involving fusing multiple data streams and online computation and feedback incorporated into complex stimulus presentation scripts.

Zeynep Akalin Acar has released a Neuroelectromagnetic Forward-modeling Toolbox (NFT) running under Linux and Matlab for building accurate BEM electrical head models from subject MR head images and/or recorded scalp electrode positions.

SCCN has also proposed development of a parallel signal processing library for electrophysiology research using new GPU-based clusters.

Mobile and Wireless EEG and BCI, Tzzy-Ping Jung, Jeng Ren Duann, and Ruey-Song Huang continued to work with collaborators Drs. CT Lin and JC Chiou of National Chiao-Tung University, to develop microelectronic systems for mobile and wireless EEG. A prototype 4-channel mobile & wireless EEG cap has been developed and demonstrated at several International Conferences and DoD meetings. The EEG cap features dry Micro-Electrical-Mechanical Systems (MEMS) sensors, miniaturized signal acquisition hardware (bio-amplifier, A/D converter, and wireless telemetry), and software for supporting non-invasive acquisition of brain and physiological activity in operational environments. Results of this study have been published in the *Proceedings of the IEEE* (Lin et al., 2008). In the study (Lin et al., 2008), a custom design signal-processing module was programmed to assess fluctuations in individuals' alertness and capacity for cognitive performance – accurate steering in a realistic driving simulator. The system delivers arousing feedback to the driver to maintain performance. This platform can also be programmed to function in ways appropriate for other brain-system interface applications. We are designing and fabricating successively higher-density systems for acquiring EEG signals without conductive paste or scalp preparation in operational environments.

ICA Group Analysis for fMRI. Testing and comparison is continuing on different group analysis approaches for fMRI data, namely ICA group analysis (ICAga), group ICA (gICA), and GLM group analysis (GLMga), based on ICA and general linear model (GLM). ICAga first decomposed individual subjects' fMRI data and selected comparable components across different subjects using component sorting methods implemented in FMRLAB. In gICA, the individual subjects' data were first preprocessed using spatial normalization and smoothing to convert individual data into standard brain coordinates (MNI template was used here). Then, the preprocessed individual image data were concatenated in time to form a surrogate data that contained data from all subjects. As a result, the comparable components from different subjects could be selected with a single component sorting process. On the other hand, GLMga analyzed the individual image data separately to extract so-called fixed effects. The fixed effects were then grouped using a one-sample t-test to summarize the individual fixed effects into group random effects. In our comparison results, ICAga clearly showed a much better fit to the individual BOLD effects regarding the task performance. As a result, it produced more compact activation ROAs compared to the other two methods. The analyses and results were documented and submitted to NeuroImage journal.

Default Mode Network Detection Using ICA. Default-mode network has attracted much research attention in recent years to study how to consistently define this network, as well as the physiological and cognitive relevance of this complicated, yet extremely consistent brain network. Analyzed in the past year were a dataset of 10 subjects who underwent fMRI scanning with no explicit task performance. The subjects were simply asked to do or think of nothing in the scanner, thus complete resting. With the help of ICA decomposition (available in FMRLAB) accompanied with component sorting based on spatial prior, we were able to consistently find the same brain network across subjects. This brain network robustly included the mesial prefrontal cortex, the bilateral inferior, the parietal cortex, as well as the posterior cingulated, resembling the so-called tripod brain areas. Surprisingly, in the results the default-mode network also included the medial temporal cortex, such as the hippocampal gyrus, the parahippocampal gyrus, and the thalamus. To the researchers' knowledge, this is the first study that revealed the integrity of this network in a single analysis.

Co-modulatory brain dynamics in continuous sustained-attention tasks. Tzzy-Ping Jung, Jeng Ren Duann, and Ruey-Song Huang recently began work at SCCN with collaborators Drs. C.T. Lin and colleagues of National Chiao-Tung University to explore how the neuromodulatory system mediates spectral activations of the distinct cortical areas (Onton & Makeig, 2006, 2007). Also developed and explored were the applications of ICA to normalized log spectral changes observed during a realistic immersive virtual-reality based driving experiment in the activities of component processes separated by temporal ICA. Preliminary results have been published in a peer-reviewed conference proceeding (Chuang et al., 2009).

<u>The DICE (Data Intensive Cyber Environments) Group</u>

The DICE Group, now an integral part of INC, is internationally recognized for research and development of innovative open source technologies for management, sharing, and full life cycle preservation of the distributed digital data that forms an increasingly indispensable part of modern research. Research focuses on topics relevant to technologies that make it feasible for research projects to grow in scale and manage petabyte-scale collections with hundreds of millions of files distributed across the globe, with topics including rules-based data management; rules-based policy enforcement; messaging in cyberinfrastructure systems; etc. This interdisciplinary research spans the fields of computer science and engineering, artificial intelligence, and archival and library science, and is carried out in collaboration with large-scale research projects such as the TDLC, as well as archival and digital library projects.

Open Source Software. DICE group research is applied in leading the core development of iRODS, the Integrated Rule-Oriented Data System, an award-winning open source middleware system for comprehensive management, sharing, and preservation of distributaries digital data. The group has made two major and one minor release of iRODS this year: versions 2.0, 2.0.1, and 2.1. Supported by the NSF and NARA, iRODS reflects more than 10 years of user-driven development and is widely used in large-scale research projects, e.g. INC's Temporal Dynamics of Learning Center (TDLC); Oceanographic Observatories Initiative (OOI); Large Synoptic Survey Telescope (LSST); Southern California Earthquake Center (SCEC); High Performance Computing (NSF TeraGrid, NASA Center for Computational Sciences (NCCS), many others. Independent evaluations may be found at irods.org/index.php/Publications. The highly configurable iRODS system is also used in the archival community in Trustworthy Repositories e.g. the National Archives Transcontinental Persistent Archives Prototype (NARA TPAP), and Distributed Custodial Archival Preservation Environments, etc., and in the digital library community by the French National Library, etc.

DICE Group Presentations:

American Association of Artificial Intelligence (AAAI) Spring Symposium 2009, Stanford, CA
Intl. Symposium on Collaborative Technologies and Systems (CTS) 2009, Baltimore, MD
Global Research Library (GRL) 2020, Taipei, Taiwan
Keynote Address in Data Integration and Management (DIM) 2009, Corpus Christi, TX
Indo-US Workshop on International Trends in Digital Preservation, INDP, Pune, India.
Position Paper at the NSF Sustainability Workshop, Indianapolis, IN
Open Repositories (OR) 2009, Atlanta, GA.
Provenance and Attribution for Published Datasets Workshop Woods Hole, MA.

AWARDS and HONORS

Terrence Sejnowski, Director **--** Elected to Institute of Medicine

Howard Poizner, PI -- ONR grant award of $1 million to expand TDLC's Motion Capture/ Brain Dynamics lab

Ursula Bellugi and **Tom Albright** -- Inducted into the National Academy of Sciences

Matthew Leonard, Graduate Student -- completed Master's research including training in neuroimaging and theories on language acquisition. Received research grants from the Kavli Institute for Brain and Mind (P.I.: Matthew Leonard); UCSD Chancellor's Co laboratories Grant, NSF (PIs: Eric Halgren, Jeff Elman; grant pending final approval).

Shelley Marquez, MSO -- Recipient of the 2009 Betsy Fraught award recognizing excellence and outstanding achievement in the management of general campus academic units

Michael A. Pitts, Post-Doc, received training in EEG/ERP methods through work with Dr. Steven Hillyard and in fMRI methods through work with Dr. James Brewer -- 3 major projects completed, resulting in one published manuscript, one submitted manuscript, and one manuscript currently in preparation.

Temporal Dynamics of Learning Center -- Passed review by National Science Foundation and is assured funding for 2 more years. The review next year will be a major one that will decide on renewal for 5 more years of funding from NSF.

TECHNICAL REPORTS

http://inc.ucsd.edu/techreports.html