International Workshop

Hard-Wired, Soft-Wired and Re-Wired:

The human being at the crossroad of evolution, brain, language, and culture

Pontifical University Antonianum, Rome
May 7th–9th, 2015

PROGRAM AND ABSTRACTS

With a grant by JOHN TEMPLETON FOUNDATION

PROGRAM

Thursday, **May 7**

3:30 – 4:00 pm	**Meeting begins.** *Welcome and Introduction*
4:00 – 5:15 pm	Michael A. **ARBIB**: *From language-ready brain to languages* + discussion (20 mins)
5:15 – 5:45 pm	*Coffee Break*
5:45 – 7:00 pm	Laurent **COHEN**: *The reading brain: neuropsychology and neuroimaging* + discussion (20 mins)
8:00 pm	*Dinner Out* (Restaurant to be selected)

Friday, **May 8**

8:30 – 12:00 am	***SOCIAL PROGRAM*** *(see at the end of this document for more details)*
12:30 pm	*Lunch at the Antonianum Monastery*
3:00 – 4:15 pm	Pier Francesco **FERRARI**: *Development and evolution of mirror neurons in primates. Implications for social cognition and communication* + discussion (20 mins)
4:15 – 5:30 pm	Masaki **TOMONAGA**: *Social perception and cognition in chimpanzees* + discussion (20 mins)
5:30 – 6:00 pm	*Coffee Break*
6:00 – 7:15 pm	Lynne **MURRAY**, et al.: *Sculpting sociality in ontogeny: reflections from experimental, prospective naturalistic, cross cultural and clinical studies* + discussion (20 mins)
8:30 pm	*Dinner at* "Arlù"*, close to the Vatican*

Saturday, **May 9**

9:00 – 10:15 am	James **STEELE**: *Archaeology, tools and language* + discussion (20 mins)
10:15 – 10:45 am	*Coffee Break*
10:45 – 12:00 am	W. Tecumseh **FITCH**: *Language as a multi-component exaptive system: building a human brain from primate parts* + discussion (20 mins)
12:00 am – 1:15 pm	Eva **JABLONKA**: *Behavioral epigenetics and the evolution of linguistic communication* + discussion (20 mins)
1:30 pm	*Lunch at* "I Buoni Amici" *(The Good Friends), close to Antonianum*
3:00 – 4:30 pm	GENERAL DISCUSSION (first part)
4:30 – 5:00 pm	*Coffee Break*
5:00 – **6:00 pm**	GENERAL DISCUSSION (second part) **Meeting ends.**

ABSTRACTS

(according to the order of talks)

From language-ready brain to languages

Michael A. Arbib
USC Brain Project, University of Southern California, Los Angeles, CA

Abstract

This talk will address the bridge from emergence of the language-ready brain (as described by the mirror system hypothesis, MSH) to the actual development of full-blown human languages, playing variations on the theme of "construction": the evolutionary concept of niche construction, the practical skill of constructing more complex objects from simpler components, and the notion that languages can be seen as combining a lexicon with a construction grammar that combines form and meaning.

I will assess the relevance of two approaches to Construction Grammar:

Luc Steels and his colleagues see Fluid Construction Grammar (FCG) as part of a larger system embedded in each of two or more interacting robots. More specifically, FCG is coupled to a visual system and a motor system in each robot. FCG has been developed to support modeling of cultural evolution of human language. I will explore the question: "If we assess the capabilities of an FCG-endowed robot, to what extent do they model underlying properties akin to the innate perceptual, motor and learning capacities of the human brain, and to what extent do they correspond to properties that the human child only gains as a result of development within a human society richly structured by prior cultural evolution?"

A (somewhat) related issue: Peter Dominey's approach to a neural implementation of a (limited portion) of CG is based on a prior model of cortico-striatal interactions underlying oculomotor control and learning. In terms of MSH, one wants to know (i) What is the analogous model for general primate manual control (i.e., shared by macaque, chimpanzee and human)?; and (ii) CanMSH be refined to support the transition from such a system to one that can support language? In the process, I will offer a preliminary assessment of how well Dominey's approach to embedding constructions in the brain stands up to the demands of such an account.

Background Reading

Arbib (2011a) combines an exposition of MSH with some ideas on the way complex imitation may have fostered the emergence of language and sophisticated tool use, with the latter building on the work of Dietrich Stout (2011). An initial linkage of diverse notions of construction (Arbib, 2012) appeared as a commentary to a target article in BBS (Vaesen, 2012). Arbib (2011b) develops the theme of niche construction by building on and critiquing the approach taken by Bickerton (2009) in his book *Adam's Tongue.* My group's perspective on construction grammar can be seen in several papers (e.g., Arbib, Gasser, & Barrès, 2014; Barrès & Lee, 2014).

Many papers explore the diverse work of Luc Steels and his colleagues on FCG (e.g., Beuls & Steels, 2013; Steels, 2013; Steels & De Bele, 2006; Steels & Spranger, 2008).

Peter Dominey's expertise in modeling the role of the basal ganglia in the macaque neurophysiology of saccades (Dominey, Arbib, & Joseph, 1995) provided the basis for his

current work on corticostriatal mechanisms in language (Hinaut & Dominey, 2013) and on the visual grounding of language in human-robot interaction (Madden, Hoen, & Dominey, 2010).

References

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Beuls, K., & Steels, L. (2013). Agent-Based Models of Strategies for the Emergence and Evolution of Grammatical Agreement. *PLoS One, 8*(3), e58960. doi: 10.1371/journal.pone.0058960

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Hinaut, X., & Dominey, P. F. (2013). Real-time parallel processing of grammatical structure in the fronto-striatal system: a recurrent network simulation study using reservoir computing. [Research Support, Non-U.S. Gov't]. *PLoS One, 8*(2), e52946. doi: 10.1371/journal.pone.0052946

Madden, C., Hoen, M., & Dominey, P. F. (2010). A cognitive neuroscience perspective on embodied language for human–robot cooperation. *Brain Lang, 112*(3), 180-188.

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Stout, D. (2011). Stone toolmaking and the evolution of human culture and cognition. *Philosophical Transactions of the Royal Society B: Biological Sciences, 366*, 1050-1059.

Vaesen, K. (2012). The cognitive bases of human tool use. *Behavioral and Brain Sciences, 35*(4), 203.

The reading brain: neuropsychology and neuroimaging

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Abstract
Patients may lose selectively the ability to read following focal brain lesions, which reveals that we possess a cerebral system exclusively devoted to reading. However, at birth, our brain is the same as the brain of our ancestors 25,000 years ago. Where then does this specialized system come from? I'll argue that it is the outcome of embedded biological, cultural, and individual evolution. In particular, this process allows for the development of a functionally specialized area, in the left occipitotemporal cortex, which plays a critical role in letter and word recognition. I'll illustrate the normal properties of this area, its relationships with the rest of the brain, some consequences of its disruption, and discuss the reasons of its reproducible localization in the cortex.

References
Bouhali F, Thiebaut de Schotten M, Pinel P, Poupon C, Mangin JF, Dehaene S, Cohen L (2014) Anatomical connections of the visual word form area. *The Journal of neuroscience: the official journal of the Society for Neuroscience* 34 :15402-15414.

Dehaene S, Cohen L (2011) The unique role of the visual word form area in reading. *Trends Cogn Sci* 15: 254-262.

Gaillard R, Naccache L, Pinel P, Clemenceau S, Volle E, Hasboun D, Dupont S, Baulac M, Dehaene S, Adam C, Cohen L (2006) Direct intracranial, fMRI and lesion evidence for the causal role of left inferotemporal cortex in reading. *Neuron* 50: 191-204.

Development and evolution of mirror neurons in primates. Implications for social cognition and communication

Pier Francesco Ferrari
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Abstract
Mirror neurons (MN) have been originally found, and investigated for years, in macaque monkeys. Their pattern of activity and the anatomical connections with the descending corticospinal pathway prompted the idea that they are involved in several behavioral and cognitive processes, such as imitation and action recognition. The existence of a similar mechanism in other primate species (humans, chimpanzees and marmosets) and in birds points to a common evolutionary pathway in which action and perception became critically coupled in order to support important cognitive functions in social cognition and communication (Bonini and Ferrari 2011). More recent studies indicate that environmental factors and sensorimotor/social experience in infancy and adulthood can induce critical changes on how this mechanism respond to and decode social stimuli. The investigations of the mirror mechanism in early development indicate that it operates in the very early stages of postnatal development, and that it is sensitive to perturbations of the social environment (Simpson et al. 2014). These studies suggest that specific brain circuits, involving parietal-premotor areas, have been preserved in the course of primate brain evolution and that their plasticity during ontogeny might have played a key role in shaping these circuits committed to process social information and in sustaining communication (Ferrari et al. 2013). MN thus may provide an original and unitary account of basic aspects of social cognition and behavior in the primate lineage, and offer new insights on the interactions between brain plasticity, early experience and sensitive periods.

References
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Ferrari P.F., Tramacere A., Simpson E.A., Iriki A. (2013). Mirror neurons development under the lens of epigenetics. *Trends in Cognitive Science* 17: 450-457.

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Social perception and cognition in chimpanzees

Masaki Tomonaga
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Abstract
Recent advances in comparative-cognitive studies on social intelligence in great apes tell us much more about their social-cognitive abilities than before. However, it is still unknown how perceptual–cognitive mechanisms underlying such complicated behavior in chimpanzees, for example, how they perceive faces and what types of information they utilize from face, how they coordinate their behaviors, and how they distinguish self and others. In this talk, I will briefly summarize our recent data on those issues in chimpanzees. Specific topics will be 1) Various aspects of face perception: Extent and limit of "faceness", 2) Various aspects of face perception: Top-down control of face detection, 3) Various aspects of face perception: Perception of self-face, 4) Various aspects of face perception: Perception of third-party gaze interactions, 5) Sense of self-agency, and 6) Behavioral synchrony in chimpanzees.

References
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Hattori, Y., Tomonaga, M., & Matsuzawa, T. (2013).Spontaneous synchronized tapping to anauditory rhythm in a chimpanzee. *Scientific Reports*, 3, 1566. DOI: 10.1038/srep01566.

Sculpting sociality in ontogeny: reflections from experimental, prospective naturalistic, cross cultural and clinical studies

Lynne Murray, Leonardo de Pascalis, Laura Bozicevic
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and Pier Francesco Ferrari
Dept. of Neuroscience, Univerity of Parma, Italy

Abstract
This paper sets out contrasting accounts of the development of early sociality; first, an 'associationist' account in which human social expressiveness develops *purely* as a function of contingent associations between non-specific infant movements and non-specific adult responses, and second, an 'intersubjective' account that assumes a fundamental preparedness in infants to link specific forms of action with specific forms of response by others, while also accommodating learning processes. The relative merits of these two accounts will be evaluated in relation to data from four sources: first, from experimental studies in which the nature of parental responsiveness to 6-12 week-old infants is varied in both 'unnatural' (still face, non-contingent) or 'natural' (an interruption) ways (Murray &Trevarthen, 1985); second, and in most detail, from a prospective study of human mother-infant interactions from the first week of life through the period in which active social responsiveness develops (prolonged gaze to the partner, vocalizations, smiles, prespeech gestures), i.e. up to ten weeks (Murray et al in prep); third, data are considered from cross cultural prospective studies of the development of infant social responsiveness, where the form of maternal responsiveness varies (Kärtneret al., 2010); and fourth, data from mother-infant interactions in clinical populations (maternal depression and anxiety) are considered (Murray et al., 1996; 2007). We show how the developing form of the human infant's social expressiveness is 'sculpted' by experience in their social environment,and how an intrinsic 'readiness' to apprehend specific forms of response supports the co-construction of shared modes of communication.

References

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Murray, L., De Pascalis, L., Bozicevic, L., Hawkins, L., Dalton, L., Vaillancourt, K., & Ferrari, P. (in preparation). Sculpting sociality in ontogeny: a prospective study of the emergence of infant social expressiveness in the first ten weeks.

Archaeology, tools and language

James Steele
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Abstract
In an interesting pair of popular science books, Gary Marcus (2004, 2009) has proposed that the human brain evolved through small numbers of genetic changes (but of large effect), and that human cognition and behavior involve processes that are often surprisingly inefficient (reflecting the fact that the brain has evolved through a process of modification of existing circuitry by genetic tinkering).
In this talk I will summarise our work on the comparative brain anatomy of humans and other living primates [3,4,5], emphasizing the approach to the evolution of form that is implicit in such allometric analyses. I will outline the debate that currently exists within that paradigm between those who see primate brain evolution as primarily governed by developmental regularities, and those who see a more adaptively-driven pattern of piecemeal ('mosaic') brain evolution. I will comment on the relevance of this approach for the first of Marcus' proposals (Marcus 2004), while also making the point that such analyses typically lack a framework for evaluating the effects of gross volumetric changes in brain size and structural composition on cognition and behavior (beyond simple assumptions that, for example, a relatively big hippocampus is 'good for' spatial navigation, or that a relatively enlarged neocortex is 'good for' social cognition).
Our own comparative anatomical analyses of the primate cortico-cerebellar system suggested that the human brain has evolved a specialization for social learning of novel motor skills. I will therefore also summarise our own and others' behavioural experiments on skill acquisition in pre-industrial technologies (stone tool making [2], pottery), emphasizing the finding that practical expertise in such tasks involving fine motor skill and high copying fidelity across sessions depends more on long periods of training of implicit motor sequences than on explicit declarative knowledge of the design 'recipe'. I will ask whether this requirement for lengthy training (cf. Ericsson's '10,000 hour rule') reflects some optimal trade-off between innate developmental flexibility and narrow learned specialization, or a 'kluge'* in the terminology of Marcus's second proposal (2009).
Finally, if there is time, I will briefly summarise some work we have also done on the evolution of language [1,6], focusing on the links to the topics just discussed.

* *n. Slang* **1.** A system, especially a computer system, that is constituted of poorly matched elements or of elements originally intended for other applications. **2.** A clumsy or inelegant solution to a problem. Source: www.the freedictionary.com

Marcus, G. (2004). *The birth of the mind: How a tiny number of genes creates the complexities of human thought*. Basic Books.
Marcus, G. (2009). *Kluge: The haphazard evolution of the human mind*. Houghton Mifflin Harcourt.

Some examples of our own work

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2. Bril, B., Smaers, J., Steele, J., Rein, R., Nonaka, T., Dietrich, G., Biryukova, E., Hirata, S., Roux, V. (2012). Functional mastery of percussive technology in nut-cracking and stone-flaking actions: Experimental comparison and implications for the evolution of the human brain. *Phil. Trans. R. Soc. Lond. B* 367, 59-74 doi:10.1098/rstb.2011.0147.

3. Smaers, J. B., Steele, J., Case, C. R., Amunts, K. (2013). Laterality and the evolution of the prefronto-cerebellar system in anthropoids. *Annals of the New York Academy of Sciences* 1288(1), 59-69
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6. Steele, J., Martelli, S., Clegg, M. (2013). Comparative morphology of the Hominin and African ape hyoid bone, a possible marker of the evolution of speech. *Human Biology* 85(5), 639-672 doi:10.1353/hub.2013.0045.

Language As A Multi-Component Exaptive System: Building a Human Brain from Primate Parts.

W. Tecumseh Fitch
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Abstract
Spoken language uses multiple components, including syntax, complex semantics, and vocal learning, that differentiate humans from our primate cousins. I briefly review data suggesting that a specific computational capacity - the ability to build arbitrary-depth trees using a context-free grammar - is a core component of syntax that differentiates us from other species. I then examine various hypotheses about how such an unusual capacity could have evolved, focusing on the neural circuits that are believed to subserve this capacity. I suggest that the notion of exaptation - putting to new use circuits evolved for a different purpose - provides a promising way to understand how something apparently novel can evolve from components that have been "repurposed" over evolution. I consider the evidence for and against three specific exaptive hypotheses, and consider the sort of data that will be needed to test among them.

References

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Fitch, W. T. (2012). "Evolutionary developmental biology and human language evolution: Constraints on adaptation," *Evolutionary Biology* 39, 613-637.

Behavioral epigenetics and the evolution of linguistic communication

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Abstract
I argue that language evolution was made possible by collective processes of socialization and enculturation such as alloparenting, cooperative foraging and tool making, which generated new communicative behaviors and emotional dispositions. These behavioral and cognitive changes were accompanied by persistent epigenetic changes, and were partially genetically assimilated through directional selection on enhanced, ever-more-plastic, social cognition. I base my arguments on recent studies in behavioral epigenetics, which include the investigation of the role of behavior in shaping developmental-epigenetic states and the reciprocal role of epigenetic factors and mechanisms in shaping behavior. These studies suggest that epigenetic changes are both products and causes of life-style changes in humans and other mammals, and can have long-term effects both within and between generations. For example, nutritional changes, traumas and learning lead to epigenetic effects that are sometimes transmitted between generations in both humans and rodents. I suggest that induced epigenetic changes played a role in language evolution, mainly, but not exclusively, through the persistent, affect-induced physiological changes that hominid socialization engendered. These processes of enculturation and socialization led to the developmental construction of human-specific social emotions, enhanced executive control, and better episodic memory, and these traits were partially genetically assimilated. The cultural-epigenetic-genetic evolution of these cognitive affective developmental dispositions facilitated information-sharing and formed the foundation for the complex social learning that is enabled by linguistic communication. I end by suggesting some ways of testing these suggestions.

References

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Social program: Visit to *Colle Celio* sites

On the morning of May 8 we will visit interesting archaeological sites in Rome, situated in *Colle Celio*, one of Rome's Seven Hills. *Colle Celio* preserves important testimonies about the origin of Christian religion in Rome. The *Basilica di San Clemente* is perhaps the most extraordinary example of superimposition of sacred architecture upon pagan constructions: buildings of the 1st century besides a mithraeum of the 2nd century were buried to build up a paleo-Christian basilica, which was then buried again between the 11th and the 12th century to erect the new basilica with the exceptionally beautiful apsidal mosaic. The *Basilica dei Santi Quattro Coronati* is in the same complex as the *Oratorio* (oratory) *di San Silvestro* that contains 12th-century frescos representing scenes of the life of Emperor Constantine. *Santo Stefano Rotondo* is the most ancient church in Rome with a circular plan; it was build upon a Roman military camp. Passing through *Villa Celimontana*, close to the *Basilica dei Santi Giovanni e Paolo*, it is possible to admire the foundations of the *Tempio del Divo Claudio*.

We will meet at 8:30 am in front of the entrance of the Antonianum University, and then walk to the sites.

Relevant websites:

Basilica di San Clemente: http://www.basilicasanclemente.com/eng/
http://en.wikipedia.org/wiki/Basilica_of_San_Clemente

Basilica dei Santi Quattro Coronati: http://en.wikipedia.org/wiki/Santi_Quattro_Coronati

Basilica dei Santi Giovanni e Paolo:
http://en.wikipedia.org/wiki/Santi_Giovanni_e_Paolo,_Rome

Santo Stefano Rotondo:
http://it.wikipedia.org/wiki/Basilica_di_Santo_Stefano_Rotondo_al_Celio