

Lecture

**Michael A. Arbib**

**Schema Theory as a Framework for Studying the Brain Mechanisms  
of Action, Passion, and Language**

**Thursday, 16 October 2008, 4.00-5.30 p.m. (including discussion)  
Neuer Senatssaal, Universität zu Köln (main building)  
Albertus-Magnus-Platz  
50923 Köln**

Language sits midway between a society and the brain of each member. Looking up toward a society we can ask how language use, even though it varies from person, coheres into what we call a *social schema* (akin to Émile Durkheim's "collective representations") that guides a newcomer acquiring the language. Looking at each individual, we can ask at the psychological level what *schemas* -- viewed as providing the elements for a distributed account of mental function -- are required to support the individual's mastery of vocabulary, grammar and the use of language. Finally, we can probe inward to the brain to seek to understand the *neural schemas* -- the schemas understood as embodied within the brain's neural circuitry. All this will be placed within the broader framework of a *schema theory* -- neural, psychological and social -- that embraces action and perception and the passions (from motivation to emotion) that provide the motor for behavior.

Extended Workshop

**The Mirror System Hypothesis: On Being Moved**

**Wednesday, 15 October 2008, 10:00 a.m.-6-30 p.m.  
Thursday, 16 October 2008, 9:00 a.m.-1.30 p.m.  
Neuer Senatssaal, Universität zu Köln (main building)**

For nearly two decades there is increasing interest in the origins of language and music (e.g. Wallin/Merker/Brown 2000; Mithen 2005; Tallermann 2005; Christiansen/Kirby 2003) and a recent interest in the neural basis of dance (Birringer/Fenger 2005; Grove/Stevens/MecKnechie 2005). The neuroscientific discovery of mirror neurons in monkey and mirror systems in humans amplified this interest. Furthermore, the importance of mirror neurons or systems is recognized as essential for an explanation of human understanding in connection with social interaction, symbolization, intentionality, and empathy. The purpose of the workshop "The Mirror System Hypothesis: On Being Moved" is

to explore the relation of the mirror system hypothesis for language evolution to music and dance and to figure out research questions that are worth further inquiry.

The workshop is based on two research programs concerning language from a linguistic, neuroscientific and evolutionary perspective: Noam Chomsky's mentalistic account of an innate universal grammar and Michael A. Arbib's action-oriented, embodied, schema-theoretic approach to language and language evolution based on the discovery of mirror neurons and systems (Rizzolatti/Sinigaglia 2008) and his idea of language readiness (Arbib 2005, 2006). The generative approach influenced research on music theory and cognition and entered into the debate on the evolution of music (McDermott/Hauser 2003; Fitch/Hauser 2004).

Unfortunately research in both fields has proceeded separately from each other. Therefore, one idea of this workshop is to bring together researchers from different disciplines such as neuroscience of music and language, cognitive archaeology, evolutionary psychology and the study of motor-behavior and dance in order to discuss and exchange their research results in the light of the Extended Mirror System Hypothesis and language readiness. The Extended Mirror System Hypothesis (Arbib 2005, 2006, 2008) states seven stages: S1 grasping, S2 mirror system for grasping, S3 simple imitation, S4 complex imitation, S5 protosign, S6 protospeech, S7 language. S1, S2 and S3 form prehomimid stages. Stages S4 to S6 distinguish the hominid line from the great apes. Hypothesized criteria for language readiness (LR) are "from hierarchical structuring to temporal ordering" (LR4), "symbolization" (LR1), "intentionality" (LR2), and "parity" (LR3). LR4 is associated with S1 and S2. LR1, LR2, and LR3 are associated with S5 protosign. The Extended Mirror System Hypothesis is considered as a neurolinguistic hypothesis that provides an evolutionary framework for neurolinguistics. The main purpose is to identify the neural mechanisms underlying language processing.

How might "music" and "dance" fit into the evolutionary scenario provided by the Mirror System Hypothesis for language? What is the relation of "music", "language", and "dance"? To what extent can "music", "language" and "dance" be considered as communication systems? How do they differ? How are cultural, archaeological, biological and neuroscientific research on the evolution of communicative systems, i.e. (S5) symbolization, intentionality, imitation (S4) related? To what extent does symbolization in music and dance exist? What is the semantics of music and dance in comparison with the semantics of language? Do compositionality and the parity principle for language hold for music and dance too? What is the role of entrainment/synchronization in dance and music? What is known about underlying neural mechanisms or systems for music and language

processing? Do they share common neural mechanisms? What is the empirical evidence? Is a combined neuroscientific and evolutionary approach to media such as music and dance promising, and is it important to the humanities?

In order to cope with these questions a closer comparative look at speech (processing) and "music" (processing) and of sign language and dance in relation to the levels S5 and S6 is needed. It seems that in cognitive archaeology these stages are termed the "evolutionary process of speciation" (Renfrew 2007). The stage of language readiness (S5) is characterized by symbolization, intentionality and parity. A crucial step in this theory of language evolution is the transition from complex imitation, stage S4 (Arbib 2006), or mimetic culture (Donald 1991) to protosign (S5) which grounds protospeech (S6) and is interwoven with protospeech.

The workshop addresses some of these questions and is organized in two parts: „On Being Moved I“ will be concerned with music and speech/language, and „On Being Moved II“ focuses on movement and dance.

(Concept: Uwe Seifert)

#### *References*

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## Program

### **Wednesday, October 15th**

#### **The Mirror System Hypothesis: On Being Moved I**

Moderation: Uwe Seifert

10.00-10.30 a.m. Opening (Uwe Seifert)

10.30-12.15 a.m. The Extended Mirror System Hypothesis for the Evolution of the Language-ready Brain (Michael A. Arbib)

12.15 a.m.-2.00 p.m. lunch break

2.00-3.00 p.m. Neural Networks for Auditory-Motor Interaction in Music Performance and Language (Ingo Meister)

3.00-4.00 p.m. The Vocal Learning Constellation in Birdsong, Music and Language: Functional Requirements and Neural Mechanisms (Björn Merker)

4.00-4.30 p.m. coffee break

4.30-5.30 p.m. Musical Communication: Evolutionary Bases of Musical Meaning (Ian Cross)

5.30-6.30 p.m. Vocal and Corporeal Gesture and the Experience of Emotion, as Related to Musical Production and Perception (Iain Morley)

### **Thursday, October 16th**

#### **The Mirror System Hypothesis: On Being Moved II**

Moderation: Jin Hyun Kim

9.30-10:30 a.m. New Findings on the Brain Basis of Music, Dance, and Language Production (Lawrence Parsons)

10.30-11.30 a.m. Dance, Language and the Brain. An Evolutionary Perspective (Ivar Hagendoorn)

11.30-12.00 a.m. coffee break

12:00 a.m.-1.00 p.m. Cognitive Structures of Movement in Dance (Bettina Bläsing)

1.00-1.30 p.m. General Discussion

Further information: Mrs. Dr. des. Jin Hyun Kim ([jinhyun.kim@uni-koeln.de](mailto:jinhyun.kim@uni-koeln.de))

## Speakers

### **Michael A. Arbib**

University of Southern California

Computer Science, Biological Sciences, Biomedical Engineering, Electrical Engineering, Neuroscience and Psychology

Born in England in 1940, Michael A. Arbib grew up in Australia and obtained a B.Sc.(Hons.) from Sydney University. He received his Ph.D. in Mathematics from MIT in 1963. After five years at Stanford, Arbib became chairman of the Department of Computer and Information Science at the University of Massachusetts at Amherst in 1970. In September he joined at the University of Southern California where he is a Professor of Computer Science and Neuroscience.

The thrust of his work is expressed in the title of his first book, *Brains, Machines and Mathematics*, based on lectures given at the University of New South Wales in the Southern hemisphere winter of 1962.

His research focuses on mechanisms underlying the coordination of perception and action. This is tackled at two levels: via schema theory, which is applicable both in top-down analyses of brain function and human cognition as well as in studies of machine vision and robotics; and through the detailed analysis of neural networks, working closely with the experimental findings of neuroscientists.

An overview of his work as of 1988 is given in *The Metaphorical Brain 2: Neural Networks and Beyond*, 1989, Wiley-Interscience. His concern for the social implications of computer science was given textbook expression in *Computers and the Cybernetic Society*. In 1983 he and Mary Hesse delivered the Gifford Lectures in Natural Theology at the University of Edinburgh, since published 1986 as *The Construction of Reality*, extending schema theory to provide a coherent epistemology for both individual and social knowledge.

At present, his work in brain modeling is complemented by research on the evolution of language. His Mirror System Hypothesis provides an evolutionary framework for neurolinguistics (cf. his edited volume *Action to Language via the Mirror Neuron System*, 2006, Cambridge University Press).

### **Bettina Bläsing**

University of Bielefeld

Department of Sports Science

The research of Bettina Bläsing is situated in the field of overlap between psychology of sports and motor control. After completing her studies in biology at the University of Bielefeld, Bettina Bläsing obtained the qualification of a Master of Science in *Applied Animal Behaviour and Animal Welfare* at the University of Edinburgh, Scotland. Here, she also had the opportunity to participate in a project at the renowned Roslin Institute. She pursued her doctorate in the department of Biological Cybernetics / Theoretical Biology working on motor control with a particular focus on experimental procedures and simulation. At the same time, she was a member of the graduate and postdoctoral program *Strategies & Optimization of Behavior*. Having served as a scientific coordinator of the graduate program *Function of Attention in Cognition* at the University of Leipzig and in a project on spatial cognition in hominids Bettina Bläsing returned to the University of Bielefeld: Since October 2006 she is a researcher in the division of *Neurocognition and Action – Biomechanics*. As part of her work she investigates cognitive processes corresponding to dance movements and co-organized the workshop *Intelligence and Action – Dance in the Focus of Cognitive Science* in October

2007. In addition, she is a responsible investigator in the field of *Motion Intelligence* within the Center of Excellence *Cognitive Interaction Technology* (CITEC) at the University of Bielefeld. Her research interests include the control of complex motor behavior, neurocognition and dance, and models of motor learning.

### **Ian Cross**

University of Cambridge  
Faculty of Music

Ian Cross is director of the Music Faculty's *Centre for Music and Science* and is responsible for teaching and research in all aspects of science and music at Cambridge. For over 25 years he has been conducting experimental research in music cognition and has increasingly turned towards the investigation of music from an evolutionary perspective (including the study of meaning, and of temporal interaction, in music, as well as the experimental archaeology of music). Publications include the books *Musical Structure and Cognition* (Academic Press, 1985) and *Representing Musical Structure* (Academic Press, 1991), both co-edited with P. Howell and R. West. He is co-editor of the forthcoming *Oxford Handbook of Music Psychology* (with S. Hallam and M. Thaut) and the of volume *Language and Music as Cognitive Systems* (with M. Rohrmeier, P. Rebuschat, and J. Hawkins). Recent and forthcoming articles deal with perceptual determinants of violin timbre, musical pitch structure in cognition, implicit learning of serial musical structure, experimental musical archaeology, meaning and music and the role of music as a communicative medium, again including an evolutionary perspective.

Ian Cross is a member of the Committee of the *Society for Education, Music and Psychology Research (SEMPRE)*, is on the editorial advisory boards of *Psychology of Music*, *Music Perception*, *AI & Society*, *The Soundtrack*, and *Cognitive Semiotics*, and from 1997 until 2000 was the Associate Editor (English language) the journal *Musicae Scientiae*.

### **Ivar Hagendoorn**

Den Haag

Ivar Hagendoorn is a choreographer, photographer and researcher. He studied econometrics, philosophy, and literature at the Erasmus University Rotterdam, Leiden University and University College London. For many years he worked as a quantitative analyst and risk manager in finance. In 2001 he was a visiting scientist at the University of Southern California, Los Angeles; in 2005/6 he was a visiting professor in the post-graduate program in choreography at ArtEZ, the Arnhem School of the Arts; he is currently a researcher at the Department of Cognitive and Affective Neuroscience at Tilburg University. In 2004 he created a full evening choreography *Communications from the Lab* for the former Ballett Frankfurt. In his research he combines insights from philosophy, cognitive neuroscience, psychology, and sociology in the study of art, with a special focus on the art form of dance. He takes up problems of neuroaesthetics, the perception of dance and the underlying neural processes, and the neural basis of dance improvisation. An example for the integration of mathematical models is given by the description of the emergence of intricate patterns and cooperative behavior in dance improvisation from the point of view of complexity theory.

Hagendoorn's work is rooted in the conviction that being an artist as well as a scientist requires an open and curious mind and that interdisciplinary research should not stop at disciplinary boundaries but can profit from the examination of art, literature, and other cultural artefacts.

**Ingo Meister**

University of Cologne  
Department of Neurology

Ingo Meister is author resp. co-author of numerous scientific publications. Using the methods of transcranial magnetic stimulation (TMS) and functional magnetic resonance imaging (fMRI), e.g. neural processes underlying language processing, movement coordination in musicians and non-musicians, musical imagery in pianists, or auditory localization are investigated. A particular focus is on the functional connection of hand motor cortex areas and areas active in language processing or language and music processing.

Ingo Meister cooperates with the *Ahmanson-Lovelace Brain Mapping Center* at the David Geffen School of Medicine, University of California, Los Angeles and the *Max Planck Institute for Neurological Research*, Cologne.

**Björn Merker**

Stockholm

Björn Merker obtained his Ph.D. in neuroscience from the *Department of Psychology and Brain Science* at MIT in 1980. Since then he has worked on oculomotor physiology in cats, on the primary visual cortex in macaques, on song development and mirror self-recognition in gibbons, and on the evolutionary and developmental background to human music. The latter interest led him to join the *Institute for Biomusicology* (Östersund, Sweden), as a result of which Merker acted as a co-editor (with Nils Wallin and Steven Brown) of the conference volume *The Origins of Music* (The MIT Press, 2000), presenting a range of contributions to an evolutionary musicology. In his own contribution to that volume he investigates the hypothesis that the rhythmic synchronization of vocalizations in combination with dance-like rhythmic movements played an important role in the social organization of early hominids. His current interests include a focus on vocal learning as key enabling factor for the role of imitation, ritual culture, and encephalization in the origins of language. In October 2007 he gave the opening lecture (addressing brain mechanisms of consciousness) in the series *The Enlightened Brain*, organized in commemoration of the 200<sup>th</sup> anniversary of the internationally renowned *Karolinska Institutet*, Stockholm.

**Iain Morley**

Cambridge University  
Department of Archaeology

Iain Morley holds a Wenner-Gren Hunt Postdoctoral Fellowship for his work on his book on the prehistory of music. He is a Fellow of the McDonald Institute for Archaeological Research, and since 2005 has been a Research Fellow of Darwin College, Cambridge. Having studied psychology for his undergraduate B.Sc. degree at Stirling University, Iain Morley took an M.A. in Cognitive Evolution at Reading University. In 2003 he was awarded his Doctorate at Trinity Hall, Cambridge, for the thesis *The Evolutionary Origins and Archaeology of Music: An Investigation into the Prehistory of Human Musical Capacities and Behaviours*. Following this, he held positions in academic administration and teaching at Cambridge as well as carrying out field research. His teaching has covered a variety of archaeology and anthropology, including courses in cognitive archaeology and human evolution. From 2005-2008 he was co-investigator with Prof. Colin Renfrew on the Templeton-funded project *The Roots of Spirituality*, dealing with early occurrences of behaviors typically considered to be components of religious practices and beliefs. In this context he organized together with Lord Renfrew the conferences *Image and Imagination:*

*Material Beginnings – The Global Prehistory of Figurative Representation* (2005) and *Measuring the World and Beyond – The Archaeology of Early Quantification and Cosmology* (2006) and has co-edited the books derived from those symposia. Another volume, *Becoming Human: Innovation in Material and Spiritual Cultures*, gathering contributions on the Palaeolithic archaeological record and the relationship between the emergence of symbolic behaviors and ‘spiritual’ understandings of the world, will be published by Cambridge University Press in 2009.

### **Lawrence Parsons**

The University of Sheffield  
Department of Psychology

Lawrence Parsons obtained his B.A. at the University of California, Irvine and his Ph.D. at the University of California, San Diego. Until 2001 he was a co-principal investigator on grants from the National Institute of Health on functions of the cerebellum and on a multi-centre program project (International Consortium for Brain Mapping); in addition he was involved in separate grants on music and brain studies. 2001 – 2003 he was Founding Director of the Cognitive Neuroscience Program, funded by the National Science Foundation (USA). He organized the symposia *Mapping Music in the Brain* (San Antonio, 2000) and *The Musical Brain* (London, 2002), was a co-editor of several neuroscientific journals, served as principal scientific advisor for the international television documentary *The Music Instinct*, and since 2003 he is a trustee of the *International Foundation for Musical Research*. In his research Parsons e.g. works on neural processes underlying hand shape and movements or piano playing as well as the neural basis of human dance. Further investigations take up the comparison of (partly overlapping) brain areas in the production of speech (sentences) and music (melodies).