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## **SCIENTIFIC REPORT**

**ON**

**ESF LESC - SCSS EXPLORATORY WORKSHOP**

**Towards “real” comparative social cognition:  
Integrating theories, terminology and methods  
across a wide range of human and non-human  
animal species**



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## 1. EXECUTIVE SUMMARY

### 1.1. OBJECTIVES, SCIENTIFIC AND ACADEMIC CONTEXT OF THE ESF EXPLORATORY WORKSHOP

The fundamental aim of the ESF Exploratory Workshop was to explore the current state of comparative social cognition in an interdisciplinary framework and to define possible future directions. Though at present there is a general agreement that understanding and explaining how human and non-human animal minds function, how humans and other animals perceive, and how they experience and comprehend their world require an evolution-based approach by presenting a broader view of cognition across a wide range of human and non-human animal species, the field is far not unified from theoretical and methodological points of view, which makes “real” comparisons between species and scientific discussions within and between disciplines rather difficult. The dual (psychological and ethological) origin of the investigation of human and non-human behaviour has hampered research to the present day and resulted in serious theoretical, terminological and methodological differences. More specifically cognitive methods and terminology were primarily developed for the study of human mental capabilities and accordingly are less applicable to species with minds less similar to that of humans. Though the increasing number of distantly related species (such as insects, fish, birds, canids, primates, humans and so on) involved in cognitive examinations is to be welcomed from an evolutionary viewpoint the scientific tools to formulate questions and hypotheses and evaluate experimental results in this diversity are not well-developed yet. A notoriously difficult problem is, for instance, how to come up with behavioural criteria in diverse species which could functionally described the same level of cognitive complexity. Developing a meaningful comparative social cognition research agenda requires a clear understanding of both the evolutionary history and the developmental constraints of the behaviour being studied. Clearly interdisciplinary research is needed to gain a broad understanding of the evolutionary and developmental processes that determine the functioning of the mind, and how it controls sociocognitive behaviour. This requires explanations at different levels of biological organisation and relies on the integration of insights from behavioural genetics, neuroanatomy, neurochemistry, neurophysiology, behavioural and human social sciences. In addition, a novel promising field is emerging in the form of artificial intelligence and robotics, where such knowledge can be put to test.

So at present the diversity of existing theoretical approaches accompanied with the seemingly unending circular debates and methodological problems prevent or slow down the development of comparative social cognition as a unified scientific field studying animal and human mind. Accordingly the central aim of the ESF Exploratory Workshop was 1) *to facilitate the development of unified theoretical background, scientific terminology and methodology in the field of comparative social cognition*, and consequently 2) *to make the field more transparent and accessible to a wider range of research areas of the biology of mind from genetics and neuroscience to robotics and human social sciences*.

To achieve this aim the ESF Exploratory Workshop brought together leading experts from several European laboratories with different scientific backgrounds and experiences with various animal species. Thus we had researchers representing numerous animal taxa (social insects, different species of fish, birds and mammals, humans), working in various fields of social cognition and behaviour

(e.g. social learning, mind-reading, communication, attachment), representing either an applied or theoretical approach (e.g. ethologists or philosophers versus veterinarians or experts of robotics), and studying different levels of biological organisation (genetics, neurophysiology, behaviour). The laboratories represented use different methodologies since the environment they work in range from natural study-sites with habituated, wild living animals to captive animal keeping facilities in zoos or research institutes through testing labs and databases of families with children or dogs volunteering for experiments. In this way the scientific community was more diverse than usual in such workshops relying on intensive discussion among participants. This strategy made the workshop especially challenging for the participating researchers, gave them an “interesting exercise” and urged them to aim toward a common language in order to inform each other.

Due to current stage of the field and the need for interdisciplinary approach of comparative cognition, with the help of the extensive international contacts of the convenors, the large majority (88%) of the scientists originally invited from a wide range of research labs accepted the invitation to attend and participated actively throughout the workshop. In total, 24 participants (18 senior and 6 young scientists) from 11 different countries (Austria, Canada, Czech Republic, France, Germany, Hungary, Italy, Netherlands, Russian Federation, Sweden, United Kingdom) took part during the three days of the highly successful meeting. The great current interest was indicated by a large number of young and senior scientists who had inquired about the possibilities of joining the workshop but had to be refused because of the already high number of participants. Its timeliness is shown by using its title as reference to describe context of another meeting of the field (see [http://www.univie.ac.at/zoology/nbs/gruenau/EG-Meeting/eg\\_meeting.htm](http://www.univie.ac.at/zoology/nbs/gruenau/EG-Meeting/eg_meeting.htm)).

## 1.2. BACKGROUND AND ORGANISATION

The workshop was convened by Dr. Zsafia Viranyi (Konrad Lorenz Institute for Evolution and Cognition Research, Altenberg, Austria) and Dr. Miklosi Adam (Department of Ethology, Eötvös University, Budapest, Hungary). It was located in the cosy Hotel Aranysas ([www.hotelaranysas.hu](http://www.hotelaranysas.hu)), near to Balaton, the biggest lake of Hungary, 150 km from Budapest taking this prestigious group of international scientists to the Hungarian countryside. The hotel provided not only a comfortable and well-equipped room for the talks and discussions but also plenty locations for other joint activities such as informal discussions during the coffee breaks and the rich meals, and various indoor and outdoor sport activities. This environment made even possible that a female research arrived with her 1-year-old baby and could participate in all workshop activities with the help of her sister. Though the workshop programme was rather tense and planned to make the meeting so efficient and productive as possible beyond these within doors activities further social events were organized, which happened to be very successful and probably quite memorable for most of the participants (for some photos of the workshop see <http://picasaweb.google.com/esf.workshop.hu>).

Organisation of the workshop – including both its scientific and practical preparation – was generously helped by cooperative work of the PhD-students and colleagues from the Department of Ethology, Eötvös University, Budapest. Albeit rules of the ESF Exploratory Workshops prevented the students from learning by participating in or by observing the workshop directly, preparation of the workshop

(see section 2.1.) and its results were internalized into the Department activities in order to let the students profit so much as possible. To acknowledge the Department's contribution the workshop is advertised on the homepage of the Department: <http://etologia.aitia.hu/main.php?folderID=863&articleID=4020&ctag=articlelist&iid=1>.

## **2. SCIENTIFIC CONTENT OF THE ESF EXPLORATORY WORKSHOP**

### **2.1. SCIENTIFIC PREPARATION OF THE WORKSHOP – THE PROVOCATIVE INQUIRY**

Keeping the purposes of the workshop in mind we wanted to ensure that the scientific discussions during the course of the workshop would be about topics with high and general relevance for the theories and methodologies of the field instead of sticking to minor methodological questions of individual studies. Further on because of the wide range of scientists participating it was expected to be useful to provide some material that might be the basis for a common language and understanding shared by the participants.

To achieve these aims prior to the workshop each participant had been asked to suggest five published or unpublished papers which she/he considers important (either productive or problematic). These papers were subject for a series of meetings at the Department of Ethology, Eötvös University. Its PhD-students and researchers read and presented them, and based on their discussion key issues of the field were identified. A 9-page questionnaire with the telling title "Provocative Inquiry" was prepared to collect a list of "outstanding" questions and debatable issues. The Inquiry presented problematic questions, scientific debates or alternative views/definitions, practical questions treated differentially and widely accepted but not well-justified, basic assumptions on the following topics and asked for the participants' view on them:

- General questions in comparative cognition
  - Defining cognition
  - Defining levels/kinds of cognitive abilities
  - The necessity for developing a common language (words plus verbs plus adjectives plus...) for describing cognition.
  - Investigating cognition through behaviour
  - Comparing mental processes across species through behaviour
  - How to compare cognition across species? ("Same for everyone, or everyone is different"?)
  - Differential attitudes toward different species
- Current debates in the study of comparative cognition
  - Testing animals in ecologically relevant but novel situations
  - Experiments in captivity and field observations
- Orienting your talk to be presented at the workshop on comparative cognition
  - Tinbergen's four questions
  - Ethology and psychology
  - Evolutionary approaches to the study of cognition
- Finding the questions you are interested in
- Interdisciplinary perspective
- Society and the science of comparative cognition

- Behaviour – cognition – consciousness – sentience
- Genes and determination
- Final (statistical) exercise

The Provocative Inquiry proved to be very stimulating and useful. The participants gave their opinion more directly, more clearly than usual at scientific meetings either in the form of answering a certain question or refusing replying it. All participants read the questionnaire before the workshop, which was reflected in the unusually high-level and theoretically general discussions during the workshop. The Inquiry was the basis for the discussion of the first evening preceding even the first talk, it gave a general framework for the talks all of which addressed the above basic questions relevant in the research work presented, and made the discussions theoretically deeper and more opened, more clearly expressed.

## 2.2. STRUCTURE AND FORMAT

Structure of 3-day workshop was adjusted to the aims of the workshop – and through them to the needs of the field – and highly corresponded with the requirements of the ESF Exploratory Workshops: 1) the speakers had relatively long time to present their research and plenty of time was reserved for discussions, 2) the interdisciplinary presentations were interspersed between the talks more closely related to the field of comparative social cognition.

Each participant gave a talk of 30 minutes that was followed by a 15-minute-long discussion. Each session consisted of two to four talks and was terminated by a general discussion of 30 minutes, which was conducted by the chair of the session who worked on a different (sub)field. Finally the entire workshop was framed by two lengthy overall discussions opening and closing the workshop. The purpose of this embedded structure of discussions was to identify problems and to provide possible solutions at the experimental level, and beyond this to clarify their wider importance, to agree on name and definition of phenomena, to provide a list of useful advises for methodological issues and practical solutions in a broader theoretical, terminological and methodological framework.

The workshop covered seven sessions that contained talks by researchers working in different disciplines and with various species. Moreover the chair of each session was from another field in order to bring a more or less external and critical view on the topic of the session:

- Conceptual issues of social cognition – chair: Pierre Jacob
- Comparative or species-specific social cognition? – chair: Thomas Bugnyar
- Communication with and perception of companions – chair: Josep Call
- Do we need “theory of mind”? – chair: Elisabetta Visalberghi
- Genes, learning and “understanding” – chair: Robert Gerlai
- Social learning as a cognitive process – chair: Gyorgy Gergely
- Cognition and physiology as reflected by philosophy – chair: Nathan Emery

## 2.3. SCIENTIFIC CONTENT OF THE WORKSHOP

After greeting the participants by the convenors and opening the meeting by the two representatives of the ESF, maybe extraordinarily, the workshop began with a

discussion. Since the workshop brought together experts from a range of fields related to comparative social cognition wider than usual in such workshops first of all the participants were requested to introduce themselves and their research interest. Interestingly, however, beyond this the participants spontaneously started to include their view of whether and how to define cognition. This lead very quickly to a vivid discussion at a general level gave a quick and articulate insight into the scientific positions of most of the participants. This introductory discussion presumably had a major role in helping the participants to follow each other's contributions and to react to them, and in focusing all further discussions on theoretically essential points having the potential to improve the field.

The first session was held by four senior experts of the field and gave a conceptual introduction to the workshop. These four speakers are leaders of labs working with different species: birds, apes, fish and dogs. Beyond it to help focusing on general questions the session was chaired by Pierre Jacob, an expert of philosophy of human cognition relying on the neurological bases of human mind.

The first talk rose a seemingly strange question: "What's so special about social cognition?". **Nathan J. Emery** argued that it is a valid question to be asking: "If social cognition isn't particularly special then why has so much research effort been dedicated to its study for the last 30 years?" He approached this question from three perspectives. First, what is *special* about social cognition? Is social cognition a cognitive module in the strict Fodorian sense? Evolutionary psychologists certainly think so, and even go further by splitting social cognition into an increasing number of micro-modules, such as a module for social exchange or cheater detection. He argued that the common metaphor for the mind as a Swiss army knife is wrong and not based on an understanding of how brains work and evolve. Is social cognition an adaptive specialization, i.e. have social species (or more specifically species living in complex, individualised societies) evolved special psychological mechanisms to aid in social interaction which non-social or less social species have not? He presented evidence that in some taxonomic groups (such as primates and carnivores) there seems to be a relationship between social group size (as an indication of social cognition) and brain size (as an indication of cognitive ability), but not in other taxa, most notably birds. Also, many species which may be classed as asocial, such as western scrub-jays, have demonstrated extraordinary socio-cognitive feats which cannot be explained by the simple adaptive specialization view. Are there specialized neural systems dedicated to social cognition? He presented evidence that social cognition, at least in the human brain, is processed by a specialized neural systems, but it is unlikely that this is a *dedicated* neural system. His second perspective was what is special about *social* cognition? Are social stimuli processed differently from non-social stimuli? Certainly in the human brain, faces appear to be processed differently from other objects, are processed by a dedicated neural architecture, are affected by inversion, are affected by brain insult (prosopagnosia) and are attended to by newborn infants immediately after birth and preferred over other objects. However, humans also attribute non-social stimuli with mental states (anthropomorphism). His final perspective was what is special about social *cognition*? For too long, research in comparative social cognition has been stifled by focusing on a search for theory of mind in non-human animals. Theory of mind is *human* theory of mind, and so cannot be found in the same form in any *non-human* animal, even our closet relatives, the great apes. Because of this, it is difficult to determine which aspects of social cognition we share with other animals, and which are unique, for

example, how important is human language? Although we have good data on so-called precursors of theory of mind, such as gaze following, pointing, gaze alternation and attention-reading, this research has largely been led from the perspective of human theory of mind rather than attempting to determine the subtle cues non-human animals use to infer and predict the behaviour of conspecifics during normal social interaction. He presented some recent work on behaviour-reading in jackdaws using conspecifics as protagonists in which the use of social information is dependent on the relationship between the model and the observer. So, if social cognition isn't a module, isn't an adaptive specialization, and social stimuli aren't processed differently from non-social stimuli, what is special about social cognition? He argued that simulation based on introspection is the only special form of social cognition because it relies on self-awareness and projecting personal experiences which cannot be constructed by reasoning alone. As such, simulation may be the purest form of social cognition, and so the least likely to be wrong. This avenue of research has been relatively untapped and so is ripe for future study in non-human animals.

The second talk, presented by **Josep Call**, began with the two traditions of which the knowledge on primate social cognition has grown out. The psychological tradition has devoted considerable research effort in the last two decades to investigating whether nonhuman animals are sensitive to the mental states of others. The ethological tradition, whose roots are even deeper than those of the psychological tradition, has devoted a considerable effort to investigate the social interactions and relationships of individuals. Although both traditions have been used to answer questions about the social cognition, until now there has been surprisingly little direct interaction between the two. The speaker presented some of the studies in which the reaction of chimpanzees was investigated to social outcomes involving the transfer, donation, and theft of food. These studies aimed at exploring whether food sharing among chimpanzees is governed by social norms shared among the individuals of a group. The talk offered a good opportunity to discuss how to merge the psychological and ethological traditions in the study of primate social behaviour and, more generally, of social cognition.

**Robert Gerlai**, a professor of behavioural genetics and neuroscience of rodents and fish presented a stimulating talk, and directly addressed the question whether we can model complex human social problems with lower order vertebrates. Though he answered the question briefly ("we do not know yet"), the example of the "autistic zebrafish" was useful to raise numerous issues one has to consider, some of which concern practical questions others more principal points. First he started with the latter ones. The fashionable buzzword "model organism" implies that we are modelling some aspects of human biology and behaviour and by studying animals we can understand the behaviour of our own species as well as its diseases. The reason for conducting research with the model organism is that we do not yet understand the biological bases of the human disease. But then we do not really know what we are supposed to model. Thus we face the "chicken or the egg" conundrum. The answer to this conundrum, some say, is that research is an iterative process: step by step we can refine our models by gaining incremental knowledge about both the study species and our own.

The second principal issue, he brought up, with using model organisms has to do with homology vs. analogy and with divergent, convergent, or parallel evolution. One can pose the seemingly unintelligible question: Is social behaviour social behaviour? Or in other words, is the behaviour we describe as social behaviour in one species homologous or just analogous to social behaviour seen in



another? Are the underlying biological processes the same or did social behaviour evolve from very different starting points establishing very different biological “solutions” in different species? Can we really assume that by studying the biological underpinnings of social behaviour in one species we will be able to understand its mechanisms in another? Is there phylogenetic “continuity”? The question is complex and the answer may differ for every single phenotypical characteristic and for every species pair compared. The literature provides examples for “no” or “yes” and also “in between” type answers. S. J. Gould shows that the insect wing originally evolved as a thermoregulatory device and only after reaching a certain size could a new selection pressure push it towards becoming an organ that supported flight. An entomologist studying thermoregulation may be at a loss as to why the organ has become that large. In two study species although the organ has the same biological origin, it may have different functional characteristics. Conversely, the bat and the bird wing have the same functional characteristics (both serve flight) but have different biological origins. On the yes side, however, have the countless examples of evolutionarily conserved DNA sequences and functional properties of such genes. For example, from fruit fly to man several molecular mechanisms of learning and memory appear to be mechanistically similar. Coming back to social behaviour and its modelling: Vasotocin of fish is a hormone similar in amino acid sequence to vasopressin of mammals and both hormones serve similar functions: they are involved in social behaviour. Thus one may indeed be able to utilize simpler vertebrates (or other species for that matter) to analyze more complex ones.

After these he turned to the practical issues. Why would one want to use zebrafish for modelling or analysing complex vertebrate social behaviour and its abnormalities including those seen in human autism? There may be many reasons. Zebrafish has been proposed to be an ideal vertebrate for this purpose because its developmental biology is well understood and because autism is a neurodevelopmental disease. The transparent and externally developing zebrafish embryo provides an excellent system in which the structure and function of the developing nervous system may be analyzed. Autism has a significant heritable component and mutations may be easily induced and identified in zebrafish, and certainly faster and more efficiently than in any other vertebrate organism. Thus, zebrafish may be an excellent hypothesis generator and molecular target identification tool. Last but not least, zebrafish is a highly social organism that shows strong conspecific preference, shoal cohesion. This latter point, the behavioural aspects of zebrafish is perhaps the most problematic from a practical standpoint. Although the genetics and embryology of zebrafish are well investigated, very few studies have been conducted on the behaviour of this species. If, for example, one wanted to conduct a forward genetic study in which mutagenized fish are to be screened for mutation induced behavioural alterations, one would have a hard time finding a fast and reliable, and automatable, behavioural test paradigm. Briefly, behavioural analysis of zebrafish is in its infancy. In line with these theoretically relevant questions the talk presented some preliminary findings and observations on zebrafish behaviour and its analysis. Simple shoal preference and shoal density paradigms and recording methods were shown to demonstrate the utility of zebrafish in genetic screening. It is not known whether zebrafish will indeed be an appropriate model system for the analysis of complex vertebrate social behaviours and how much we can generalize from the discoveries made with zebrafish to other species. However, based on the identification of evolutionarily conserved mechanisms in such complex traits as

learning and memory across a broad range of species, that it is not unlikely that analysis of social behaviour of zebrafish will shed some lights on the mechanism of social behaviour of other species including our own – he concluded.

The talk brought up several important questions based on behavioural empirical data of a low order model species, which however proved to be simulating for researchers working on cognition in birds and mammals. An especially lengthy and fruitful discussion developed on the merits and limits of using animal models based on their homology vs analogy with the human species and on the question what kind of verification is needed to such species comparisons.

**Adam Miklosi's** talk, as that of the senior convenor, was to stimulate a comparative and analytical view of the following talks and to initiate fundamental discussion among the participants. He investigated the existing aims and means of comparative social cognition and proposed novel, moreover sometimes provocative ones. One of these was to define 1Cog as the currency of all cognitive investigations exchangeable across various species and descriptive in its quantity for the different levels and kinds of cognition. This need he justified by the enormous growth of the scientific literature on studying the cognitive aspects of social behaviour in the last few years. At the beginning of this development the main emphasis was on finding evidence for the evolutionary force of sociality. Living in a physically more complex niche (the social group) could result in novel challenges for individuals. Accordingly, this scenario leads to the emergence of specific complex skills which would not have evolved in a simpler environment. Although it started with human-chimpanzee comparisons (along traditional lines) it soon developed into a comparative endeavour because researchers applied the methods to a broad range of species. In the speaker's view these first years should be regarded as the first exiting years of discover a previously unknown terrain during which necessary experience has been collected. What is needed now is a critical evaluation of our present knowledge and a common ground for future systematic work. He argued that (1) comparative social cognition (CSC) should be framed in ethological terms based on Tinbergen's 4 questions. (2) This approach offers a possibility to distinguish between functional description of behaviour and cognitive (mechanistic) explanations. (3) There is a need to outline the relationship between non-social and social cognitive processes, which should be based on a common terminology but, which is able to incorporate the specificities of social systems (if there are any!). (4) Methodological problems need clearly more attention because in this case methods applied in non-social cognitive systems are often not applicable in CSC. These include problems with the sample size, the experience of the individual, interaction between experience and performance, and the recognition of species differences. In order to illustrate these above problems the participants were provided examples from recent literature with focus on human-animal (dog, cat, chimpanzee) communication.

Aim of the second session was to provide an overview of the broad nature of comparative social cognition in terms of the species investigated, the methods used and the scientific problems attempted to examine. Accordingly in this session there were talks about social learning in social insects, interspecific relationship and attachment in domestic dogs and social cognition in domestic pigs, goats and apes. Moreover the session was chaired by an expert of bird social cognition, Thomas Bugnyar.

The first talk, in which **Zhanna Reznikova** searched for “the formula of happiness” in social insect communities, proved to be very popular and influential. The main theme of her report was social and cognitive specialisation in animal communities. Individual’s specialisation can be based on its social role within local community, that is, social specialisation. Behavioural specialisation is based on individual’s inherited preferences of certain stimuli, searching images and searching rules. Cognitive specialisation is based on individual’s gift for certain problems. In some situations behavioural, social, and cognitive specialisation can be congruent. Perhaps in such situations individuals are lucky to be in harmony with their mentality and environment. May be this is the formula of happiness.

It is an intriguing problem for cognitive ethologists: is there a room for intelligence within frames of social specialisation in animal communities? Ants are good candidates for considering the problem of social and cognitive specialisation. Although the majority of models describe collective decision making in ants as being based on inter-relations of carriers of relatively simple behaviour repertoires, these insects are known as doing many clever things including sophisticated spatial orientation, information transfer by means of distant homing, and social learning. Her field and laboratory experiments have demonstrated that high intellectual capacities in social insects’ families may be restricted to only a few individuals (e.g. concept formation in bees, navigation of ants in mazes consisting of two circles). To answer the question how “top ten” individuals place their intellectual potential at the service of the family she considered two previously unknown ways of propagation of new behavioural traditions:

1. direct information transfer between individuals which learn something really new and pass this information to certain members of their community,
2. initial performances by a few carriers of “at once and entirely” behavioural patterns that are wired in their behavioural repertoire.

The first way of information transfer is based on inter-relations between highly “intellectual” scouts and small groups of foragers that are individually related with certain scouts. This sophisticated way of information transmission has been studied on ants during many years and the developed “ants’ language” has been described. However, recently she has found the second (and more universal) way of propagation of new behavioural traditions in local populations studying complex hunting behaviour in ants. Since the idea of local “hunting culture” in ants arose she tried to reveal experimentally the role of social learning in springtail hunting. These laboratory and field observations have demonstrated, it took from several weeks to several months to build up the character of a successful springtail hunter. Further examinations of naïve *Myrmica* ants revealed more details of the scenario of hunting behaviour, and showed that the specific stereotype of hunting behaviour may be expressed as an integrated set of behavioural sequences. However, only in a small proportion of ants was the hunting behaviour expressed at early age.

Performing of novel tasks such as switching to mass jumping prey possibly includes sophisticated mechanisms of individual and social learning. One can assume that presence of individuals equipped with an inherited complete stereotype is necessary for triggering this stereotype in other members of the population. We can call this strategy *triggering dormant behavioural patterns*. Carriers of whole patterns to be spread serve as catalysts of social learning. Triggering of dormant behavioural patterns can be based on a cumulative effect and then tuned by individual experience of observers. A nice element of the talk was the comparison of ant results with those obtained on vertebrates. It enabled

the speaker to suggest that it could be adaptive for populations to have dormant “sketches” of complex behavioural patterns being implemented on several carriers and then distributed by means of social learning. Development study of tool use in New Caledonian crows could be supportive for this hypothesis. Further on there are several field observations and experiments illustrating the role of the cumulative effect in social learning either in rats or in pigeons. In cases of triggering dormant behaviour patterns social learning underlies species’ predisposition to learn certain behaviours and does not require feats of intelligence from animals. In the absence of such predisposition in “pupils” innovations should die with the death of “tutors”. The alternative for the animals is to be intelligent enough to quickly grasp and spread innovations. It might be that this option is implemented in some populations of primates and dolphins but it also might be that even in cases of “clever teaching” we meet the combination of innovative and predisposed behaviour. One can say that preparedness is the best teacher for animals.

The following talk by **Paola Valsecchi** was about dog-human relationship and attachment and, as such, was indirectly related to social cognition and directed the attention to the social relationships which in various species has already been proved to have an essential role in the manifestation of social cognitive abilities. Cognitive abilities play a critical role in allowing the individual to appropriately adapt to a complex and variable physical and social environment. Studies in comparative social cognition aim at understanding how social living have shaped the cognitive structures that control different aspects of behaviour. Thus, the term social cognition refers to a range of social phenomena including recognition and categorization of conspecific and their emotions, the development and management of social relationships, the acquisition of novel skills by interacting with conspecifics, the manipulation of others by means of communicative signals and the competence to perform joint cooperative actions. Most studies on these topics have been carried out on nonhuman primates (apes and monkeys); however in recent years there has been an increasing interest in studying cognitive processes from a more comparative perspective and research on different vertebrates and invertebrate species. Within this new framework, dogs’ social-cognitive abilities have received most attention. A large number of studies demonstrate that the dog is a species with considerable socio-cognitive and communication skills and a natural disposition to cooperate with humans. For example, there is evidence that dogs can learn socially from conspecifics or human beings, are able to use different human social signs (e.g. looking or pointing) as information sources to solve a task, and engage in complex communication with people.

Nowadays, human beings represent the most relevant component of dog’s social environment and therefore, the dog-human relationship is likely to play an important role in all aspects of a dog’s life including its cognitive performance. The nature of the dog’s affectional tie with its human partner has been investigated in a number of studies. The presentation focused on main results obtained in the past years using a modified and adapted version of Ainsworth’s “Strange Situation” test to assess dog-human attachment in different contexts. According to an ethological perspective attachment can be considered as a particular kind of affectional bond that endures over time, involves a specific individual and is emotionally significant: it involves providing care and comfort and/or obtaining security and comfort from the relationship. In the presented studies the SST procedure was used to investigate attachment in dog-human dyads with different characteristics (pet dogs living in the same house since puppy-hood and dogs with an experience of

abandonment, guide dogs during the selection process to become guide dogs and with different attachment figures). The results of these studies: 1) support the hypothesis that the behaviour of modern pet owners towards their dogs is an interspecific parental behaviour, and suggest that behaviours evolved to provide care and comfort to human infants have been co-opted for interacting with other social partners; 2) show that the relationship between adult dogs and their human companion is an affectional tie that in a number of respects can be considered as an attachment bond; 3) highlight differences in the bond based on dogs' previous experience (i.e. abandonment, training); 4) indicate the importance of integrating behavioural and physiological measurements in investigating social relationship. Overall, these results in accordance with those of other researchers underline the need to consider the "experimental" dog as a complex system made of cognitive abilities, affectional relationships, both affected by unique previous life experiences. In fact, only very few studies have looked at the relationship between the human/dog attachment bond and cognitive abilities. Furthermore there are no studies systematically integrating behavioural and physiological data relating to the dogs' cognitive abilities in different social and environmental situations (differences in training programs, relationship with the owner, environment).

The third talk presented by **Suzanne Held** provided "a view from the trough" and introduced two studies in which paradigms to test visual perspective taking in primates were modified and applied to investigate the social cognitive skills of domestic pigs. The comparison is even more interesting because when it comes to brains, pigs are no primates, cetaceans or corvids. The traditionally cited allometric relationship between log body and brain sizes gives slopes of 0.3 for both domestic and wild types of *Sus scrofa*. This is well below the mammal standard of 0.53-0.75 (depending on author). Not only that, but pig domestication has also resulted in a relatively greater decrease in neocortex size than in total brain size. Yet the reported studies found some striking similarities in the behaviour of domestic pigs compared to that of brainier species in two classic social cognition tasks: Menzel's informed forager task and a visual perspective taking task based on Povinelli and colleagues' work in the 90s. Social cognition tasks such as these have a proud history of divergent interpretation and polarised debate. One aim of this presentation was to continue this tradition. Agreeing with Povinelli and Vonk (2003) the speaker questioned whether recent research on chimpanzee visual perspective taking is necessarily indicative of some form of mental state attribution. She did so here by drawing on the parallels between the primate work and her own. She also discussed the cognitive interpretation of behavioural tactics employed by exploited subordinates in Menzel's competitive foraging task. Again she did so by drawing on her pig work, which suggests that deception-like tactics can develop without positive reinforcement, most likely as the result of negative reinforcement through displacement.

The final talk of this session went on with the comparison of relatively far related taxa. **Juliane Kaminski** reported some studies on visual perspective taking and mental state attribution in apes, domestic goats and dogs. Human social cognition is in many ways outstanding compared to other species as humans have the ability in some situations to make inferences about other individuals' attention, visual access, goals, beliefs, desires and knowledge. These social cognitive capacities are widely referred to and summarized with the term "theory of mind". One goal in comparative psychology is to investigate to which degree the cognitive capacities underlying human cognitive skills are *uniquely* human or shared at least to some degree with other species. Investigating the social cognitive capacities of

other species may help as to identify the selection pressures at work during evolution of e.g. theory of mind. Primates are considered primary candidates for the investigation of sophisticated social cognitive capacities because they are humans' closest living relatives and from a phylogenetically point of view can be expected to share some cognitive skills with humans. However, to get a broader picture of the evolutionary processes at work it is important to also include non-primate species. The talk presented a series of studies all conducted with group living mammals namely goats, dogs and apes on their ability to take the visual perspective of others. The results suggest that understanding whether others visual access to an object is or is not obstructed (Level 1 perspective taking, Flavell 1978) might be more widespread in the animal kingdom than formerly thought. However, even if non-primate mammalian species understand something about others' current visual access, there is evidence that chimpanzees also have quite a flexible understanding of others' past visual access. In this study a subject and a competitor took turns choosing from a row of three buckets. An initial hiding event established one piece of food as "known" and another as "unknown" to the competitor, while the subject knew the hiding location of both. When the competitor chose first, both chimpanzee and human subjects subsequently preferred the bucket containing the unknown piece of food (but not when the subject herself chose first). Subjects were thus able to guess where a competitor had just searched for food, based on what they had previously observed her observing. These results are most plausibly explained by the capacity of chimpanzees to determine what others know have just seen. Whether non-primate mammalian species share this same ability is yet unknown.

After the extensive discussion of the first day about mental state attribution and the possible methods to exclude associative explanations in the experimental investigation of these high level cognitive capabilities the second day began with a session about communication. Subjects of these three talks were the use of human given cues to locate hidden food in various animal species, other forms of communication between dog and humans and even more between robots and humans. This session of the scientific examination and practical application of the smart use of observable behavioural cues was chaired by Josep Call who often argues for the chimpanzee's deeper understanding of others' behaviour.

**Marta Gacsi** reported old problems and new data (and in this way, new problems) concerning the comprehension of human gestural cues in several non-human species. One could ask why it is so interesting, whether horses or foxes understand the human pointing gesture? What do these results add to the advancement of ethology or even to cognitive science? Can we really draw conclusions on the development of human cognition, or on the events of domestication on the basis of the results of such studies? Yes, but only on one condition. The intriguing debates on the major theories are based on the results of several comparative investigations carried out using rather different methodology. Even evolutionary theories should be built only on maybe scarce, but reliable data, or they remain promising hypothesis, not more. Being sometimes strict constraints on the possibilities to do comparative research, for example the limited number of available subjects, one has to balance on a narrow lane to find the optimal but still respectable solutions. There are more possible phenomena along which one could build up some scaffold to explain and arrange the so far available data on the comprehension of the pointing gesture: sociality, evolutionary relatedness to humans, enculturation, domestication, learning abilities, etc. Knowing, however, the

wide range of species where convincing data is available on the comprehension of (distal momentary) human pointing: e.g. dog (*Canis familiaris*), cat (*Felis catus*), dolphin (*Tursiops truncatus*), seal (*Arctocephalus pusillus*), orangutan (*Pongo pygmaeus*) – and according to new data – the wolf (*Canis lupus*), it is obvious that not one simple characteristic can be accountable for this cognitive ability. From the cognitive aspect the communicational and even the referential feature of the human gestures would be of great interest, and this way the promising candidates would be the dolphin, the apes and the dog. But the not so „successful” species are also worth to investigate in simpler tests a) to have a positive control of their performance, and b) to search for some possible graduated or partial development of such abilities.

In the case of the most widely tested species, the dog, there are some new data available on a compellingly large sample (N>200) which opens the door to investigating such questions as the differences by gender, age, breed, and even the role of environmental or learning factors. Moreover, repeated tests performed by the same individuals provide evidence in different aged dogs on the stability of the performance in time. Some chewing over methodological questions may seem to be not fascinating enough but can help a lot in future research. It is difficult to organize existing data and to plan new tests and this way obtaining more easily comparable data without agreeing on what „human pointing” means, how we can define „successful performance” and when we can be sure that success in a test really refers to the manifestation of the “ability” or “capacity” in question.

The following talk by **Daniel Mills** was also about dogs but in this case gaze bias was proposed to be a method to investigate social cognition in dogs. This method has often been suggested as applicable for comparisons across a wide range of species. This study confirmed this view providing stimulating results in comparing dogs and humans. The perception of human faces has shown that, in people, there is a natural gaze bias towards the left visual field (i.e. to the right side of the facial image). Such bias is not generally shown towards inanimate symmetric objects, suggesting that this bias results from a specific lateralisation towards the right hemisphere of the brain for the ability to process facial information. In addition, it has been shown through the use of facial chimeras that associated with this gaze bias, there is also a bias in the extraction of information towards the left visual field of the observed face. This includes information relating to the recognition of the sex and emotional state of the observed face. Recent work with macaques has suggested that such visual bias also occurs in this species, supporting lesion, electrophysiological and brain imaging studies which have suggested that these two species share a very similar neural basis to their perception of faces. The lateralisation of facial perception requires differentiation of faces from other visual stimuli and may therefore be a potentially useful tool for the demonstration and investigation of social cognition in other species, since the recognition of faces is an essential prerequisite for higher level social communication in visually dominant species. Left bias associated with right cerebral dominance is also associated with more emotional behaviour in dogs and other species.

The research group from the University of Lincoln has therefore begun to investigate the potential of this procedure to examine social cognition in dogs, who offer an interesting and potentially useful non primate model of certain human capacities. It is thought that dogs have co-evolved with humans in the domestic environment and been subjected to selective pressure to optimise their interspecific communicative abilities. Recent work suggests that dogs may have been selected for attachment and attention to people and that this is one of the features

differentiating this species from their close relative the wolf from whom they are descended. It is therefore of interest to examine whether dogs show a similar gaze bias in their response to facial images and to investigate the biological and psychological basis of these processes. Initial results suggest that dogs do indeed show a left visual bias in their gaze towards human faces but interestingly this bias is not shown towards either symmetrical macaque or symmetrical dog faces. Nor is any general bias shown towards inanimate objects or inversions of the latter two faces. However, unlike any other species investigated to date, dogs do show a left visual bias towards an inverted human face. The speaker accordingly suggested that these specific results reflect a special bias towards the visual processing of human faces by dogs which is compatible with their normal communicative strategies and current theories concerning their evolution. Namely dogs, unlike humans or macaques, will often roll over in greeting people and may thus frequently view inverted human faces. The ability to extract information from either the upright or inverted human face may be an important adaptive strategy, especially as the emotional content of these faces may be of immediate adaptive behaviour significance. Dogs may not show such bias towards macaque faces because of their unfamiliarity or irrelevance compared to human faces, although the differentiating criteria remain to be established. However a failure to show such bias towards dog faces might reflect a reduced dependence on visual facial processing in the initial assessment of conspecifics, with non-facial greeting and olfactory cues perhaps being of greater significance.

After several aspects of human-animal communication the discussion came to robot-human interactions, and **Shaun Lawson** presented some issues on how to apply behavioural knowledge in robotics to formulate social relationships with computers and other machines. Human-computer interaction (HCI) is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them. A major concern for HCI researchers is how to construct interfaces to future ambient and pervasive technologies which are naturalistic, unobtrusive and implicit. Perhaps in response to this there exists a good deal of well-established research which attempts to identify aspects of human-human communication (such as gesture, language and facial expression recognition) and implement these as modalities in human-computer interfaces. Such an approach is fraught with difficulty – frequently, reported work will ignore the complexities raised by context and culture, whilst recreation of interfaces which are ‘too-human’ can fall into the trap of the so-called uncanny valley. One possible, and potentially very manageable, alternative to using aspects of human-human social cognition as inspiration and models for human-computer interaction is to consider human-animal interaction.

Sustained consumer interest in off-the-shelf robotic animals such as Furby, Aibo, i-Cybie and RoboPet, and the commercial success of computer-games such the Tamagochi, Catz and Dogz, and, in particular, Nintendogs, provide convincing evidence of the widespread appeal of interacting with artificial, albeit rather basic, representations of creatures. As the designers of such toys and applications are no doubt aware, an accepted consensus within anthrozoologic research is the quantifiable positive effects of human-animal relationships. Accordingly, E.O. Wilson used the term biophilia to express “the connections that human beings ... seek with the rest of life”, and argued that such cravings are determined by a biological need. Despite coinage of phrases such as technophilia, to-date no link



has been explored between such socio-biological theories and human interactions with artificial systems.

This presentation considered, from a computer science standing, the future role that interactive artificial creatures will play in a society populated with pervasive computers, personal robots and ambient intelligence. Will such entities continue in a low-key role as casual entertainment devices or will they, as some researchers predict, become interfaces for all manner of interactions with larger networks of pervasive systems? Other possibilities include the idea that virtual pets will go on to replace real ones, whilst interest in generic personal robots is certainly rising. A recent call for research in Europe advocated interfaces for robots which will be “present in everyday human environments” whilst, the South Korean government is funding a strategy designed to put service-robots in every domestic household within ten to fifteen years. There are dissenting voices however which reiterate the position that computers and virtual agents can, fundamentally, never be truly social entities. Additionally, Sony recently signalled the end of their research and commercial activities in personal and entertainment robotics.

After the morning session on the use of observable, behavioural cues in various interaction the first afternoon session explored the presence of high level cognitive abilities and related phenomena (e.g. mental state attribution, culture) in non-human animals and young infants. We could listen to two talks on bird-cognition and one on imitative learning in human children, which were chair by Elisabetta Visalberghi, an expert of social learning in monkeys.

**Nicola S. Clayton** presented several experimental studies on counter espionage by food-caching Western scrub-jays. Like many food-caching animals, Western scrub-jays hide food for future consumption and rely on memory to recover their caches at a later date. In the case of scrub-jays, we know that they form highly accurate memories of what they have cached where and when on the basis of a single past caching event (Clayton & Dickinson, 1998). These caches are also susceptible to theft, however, and indeed up to 30% of caches are lost each day to pilfering competitors. Unlike most other food-cachers studied to date, members of the Corvidae, a family of birds that includes the ravens, crows and jays, are capable of observational learning of food cache location. For example, western scrub-jays can observe another bird storing food, remember the sites where the food had been hidden and subsequently recover those caches more accurately than conspecifics who were not given the opportunity to observe another individual caching the food (Clayton et al, 2001). Successful pilfering by using observational memory may require an understanding of allocentric space because the potential thief will often be in a different position to the cacher when the caching event occurs. Watanabe and Clayton (in press) compared the cache recovery accuracy of pairs of observers that watched a demonstrator cache food. Although observers were more accurate when they had observed the caching event from the same viewing direction as the demonstrator than when they had watched from the opposite direction, all the observers performed much more accurately than expected if they had been searching randomly. Furthermore, their accuracy was not affected by whether or not the caching tray was rotated. Taken together, these results suggest that western scrub-jays have excellent observational spatial memory and that they have little difficulty with mental rotation.

Cache theft is particularly problematic for corvids because such pilferage need not be entirely fortuitous but instead they can rely on observational memory. Consequently, a jay can wait until the cacher has left the scene and then steal the

caches it saw being made at will, whenever it is hungry, and without relying on successfully displacing a possibly more dominant cacher (Dally et al, 2006a). Bugnyar and Kotrschal (2002) suggested that the capacity for observational spatial memory in corvids provided the catalyst for an 'evolutionary arms race' between cachers and thieves, such that the thieves should develop methods for observing cachers as unobtrusively as possible, and the cachers develop strategies to counter the risk of cache pilferage. Furthermore, Emery, Dally and Clayton (2004) argued that, because corvids such as the western scrub-jay take the role of both cacher and pilferer, this role-taking has led to a refinement of increasingly more sophisticated, cognitively-based cache protection and pilfering strategies.

In a series of experiments, Dally, Emery and Clayton have shown that the jays engage in a number of counter-strategies to protect their own caches from theft, specifically when other conspecifics have the opportunity to watch them cache (e.g. see review by Clayton et al., in press). For example, the jays prefer to hide most of their caches behind barriers, or capitalise on shade and distance as a way of reducing what the potential thief might see (Dally et al. 2004, 2005). The jays do not place all their caches in one place, however, perhaps because unpredictability provides the best insurance against pilfering (Emery et al, 2004). Furthermore, when observed by a potential pilferer at the time of caching, experienced jays that have been thieves themselves in the past take further protective action (Emery & Clayton, 2001). Once the potential pilferers have left, they move any caches those observers have seen, re-hiding the food in new places. However, naïve birds that had no thieving experience did not do so. The inference is that the jays that had been thieves in the past engage in experience projection, relating information about their previous experience as a pilferer to the possibility of future theft of their own caches by another bird. By focusing on the counterstrategies of the cacher when previously observed by a potential pilferer, these results raise the intriguing possibility that re-caching is based on a form of mental attribution, namely the simulation of another bird's viewpoint (Emery & Clayton, 2004, Emery & Clayton, in press). Furthermore, the jays also keep track of which observer was watching when they cached and take protective action accordingly, thereby suggesting that they may also be aware of others' knowledge states (Dally et al, 2006b).

The next talk introduced another intriguing species of the family Corvidae, the ravens. **Thomas Bugnyar** talked about studies on socio-cognitive abilities in ravens that have been suggested to be linked with mental state attribution in humans, and was highly acknowledged for his thoroughly controlled experimental designs. Dealing with a complex social world requires sophisticated knowledge about others, allowing individuals to predict, and manipulate, the behaviour of potential competitors as well as cooperation partners. However, the ability of judging others' responses may be qualitatively different from a human-like understanding that the others' behaviour is guided by mental states such as perceptions, intentions and beliefs ('Theory of Mind'). Depending on the birds' ability to remember, and pilfer, food caches they have seen others make, he and his colleagues tested the response of ravens to conspecific competitors that could, or could not, see the caching and thus would likely face a high, or low, threat of pilfering. Subordinate birds were quicker in approaching caches with previous observers ('knowers') rather than non-observers ('guessers'), even though they got a head start and thus could not orient on the competitors' movements. When confronted with multiple caches, birds distinguished between caches that were inside and outside the view of a competitor at the time of caching, even though at the time of choice the competitor could see all food pieces inside the caches and

thus was unlikely to orient towards a given cache. However, birds did not distinguish between caches when they could see conspecifics during caching but the view of those competitors towards the caches was blocked by opaque curtains, indicating that ravens were not simply associating the presence of a raven with a particular caching event. Besides controlling for possible behavioural cues associated with seeing in pilfer-experiments, we explicitly tested ravens for their ability to use social cues to find hidden food in object-choice experiments. Interestingly, birds performed at chance level throughout the study or improved only after considerable training. Furthermore, testing ravens with simple feature discrimination problems (colour, form, size of objects) revealed that they usually needed about 30 trials to reach criterion. These findings stand in contrast to all pilfer-experiments in which ravens performed correctly from the very onset. Studying the birds' ontogeny of caching, however, showed quite some improvement over time in respect to where to cache safely and when to protect their caches from conspecifics. Notably the amount of playful caching of non-edible items, and the resulting interactions over those caches, appeared to shape the birds' performance when caching food. Taken together, these results support the assumption that ravens are capable of judging the consequences of others seeing the making of caches, i.e. they understand that visual barriers affect the others' behaviour at pilfering. Their judgment is hardly affected by experimental controlling and/or manipulating behavioural cues given by conspecifics nor can it be explained by discrimination learning during the experiments. Experiencing pilfering in daily life, particularly in early stages of development, seems to be necessary to acquire the knowledge to judge the others' behaviour and intentions. Whether or not ravens interpret this knowledge to themselves in mental terms remains an open question.

The third talk by **Gyorgy Gergely** brought a new species, the human into the comparative picture, and related developmental psychology and animal cognition to each other. The presentation first confronted learning about and learning from other mind. Broadly speaking, the unique characteristics of the social and cultural environment that humans are born into represent two major types of species-specific challenges for early social-cognitive development that human infants must be pre-adapted to meet. The first challenge is the nature of early human cultural learning. Already during the first years of their life human infants fast-learn a remarkably large amount and diverse forms of cultural knowledge and skills that belong to a variety of different knowledge domains (Bloom, 2000; Carey, 1985; Keil, 1995; Casler and Kelemen, 2005; Gergely and Csibra, 2005, 2006; Meltzoff, 1988, 1999; Gergely et al., 2002, Tomasello et al., 1993; 2005). Importantly, they do so even when these cultural forms are – at least, partially – cognitively 'opaque' to them (Gergely and Csibra, 2006) in so far as they have no full cognitive grasp of some relevant aspects of their causal mechanisms, teleo-functional design structure, intentional rationale, adaptive function, etc. In fact, cognitive opacity of content for the learner and/or the user is a characteristic property of many human cultural forms that may involve arbitrary and conventional features, or conceptually obscure, apparently contradictory, or only partially understood (or understandable) aspects, or they do not appear to have (and may de facto lack) any clear adaptive value. A remarkable fact about human cultures and cultural transmission processes is that in spite of their cognitive opacity, many such cultural forms, practices, and beliefs show sufficiently high-fidelity social transmission, resistance to modification and change over time and across generations, and, in general, seem sufficiently protected against the danger of entropy and eventual extinction from culture over the generations (e.g., Sperber,

1996; Sperber and Hirschfeld, 1999; 2004; Boyd and Richerson, 1985). So what are the specific characteristics of human cultural transmission processes that can account for the faithful and efficient transmission, maintenance and spread of vast quantities of cognitively opaque cultural knowledge in human cultures? In this regard, the central challenge for understanding early social cognitive development is to answer the question whether there are human-specific cultural learning mechanisms that have evolved to ensure the fast and efficient inter-generational transfer of cognitively opaque cultural knowledge.

The second challenge is the development of understanding other minds. Young children develop an early comprehension that other people have minds that represent the world. They must come to appreciate that others' actions are best understood as being caused by the contents of their representational mind states and the mental attitudes they hold towards these contents. In other words, to cope with the large variability of human behaviours observed under different contexts, young children must come to apply a mentalistic causal theory of action (a 'theory-of-mind') that involves sophisticated mindreading skills.

Further the speaker introduced their hypothesis of human 'pedagogy' (Csibra and Gergely, 2006; Gergely and Csibra, 2005, 2006) as Mother Nature's solution to the first challenge raised by the need for efficient intergenerational transmission of cultural forms and practices that are cognitively opaque to the naïve learner. Pedagogy is hypothesized to be a specialized human-specific cognitive adaptation, a relevance-guided social communicative learning device of mutual design that has evolved to ensure the fast and efficient intergenerational transfer of relevant cultural knowledge from knowledgeable to ignorant conspecifics. Pedagogical knowledge transfer is triggered by specific 'ostensive' communicative cues (such as eye-contact, contingent reactivity, the prosodic pattern of 'motherese', and being addressed by one's own name). Infants show special and very early sensitivity to such ostensive cues (see Csibra & Gergely, 2006, for a review of evidence) that signal the teacher's communicative intention to manifest new and relevant knowledge about a referent object. According to pedagogy theory ostensive cues trigger a special receptivity and fast-learning mode in the infant leading to immediate binding of the new information to the representation of the referent. Furthermore, ostensive cues trigger a tacit 'generalizability' assumption leading infants to expect that the other's knowledge manifestation will convey information that is generalizable to the object kind the referent belongs to (i. e. it is semantic rather than episodic information). Finally, ostensive cues trigger a tacit 'universality' assumption leading infants to assume that the manifested information will be publicly shared universal cultural knowledge available to all people (not only to the person demonstrating it to the infant).

After introducing its theory pedagogical knowledge transfer was contrasted to imitative learning as alternative mechanisms of cultural transmission. First the currently dominant alternative models of human cultural learning were described that consider imitation and imitative learning (e.g., Meltzoff, 1996, 2002; Rizollati and Craighero, 2004; Tomasello, 1999; Tomasello et al., 1993, 2005) as the human-specific capacities that serve as a social transmission mechanism that ensures the fast and efficient inter-generational transfer of cultural knowledge in humans. The basic assumptions were considered about the underlying mechanisms (such as direct action mapping, motor and mental simulation, and identification) that these models postulate and will critically contrast their ability to account for some relevant recent findings from the domain of early imitative learning of novel means actions and artefact functions comparing them with the

alternative account offered by pedagogy theory. Based on both empirical and theoretical grounds it was argued that pedagogy theory provides a better answer to the riddles raised by the unique characteristics of human cultural learning and that it offers a promising new perspective for how to reconceptualise and study the nature of human cultural transmission processes in the future.

In the second part of the talk the implications of pedagogy theory were explored for reconsidering the nature of the early development of understanding other minds: the second basic challenge that theories of early human social-cognitive development have to face. First some currently popular simulation- and identification-based theories were critically examined that explain young infants' early emerging capacity to interpret others' object-directed expressive behaviours (such as their object-referential emotion expressions) and their ability to functionally engage adults in different forms of triadic interactions (such as social referencing or protodeclarative pointing) as examples of early forms of 'mindreading' that are driven by and serve the primary human functional motive to 'share' one's own mental states with those of others. These views were contrasted with the alternative interpretation for the same phenomena offered by pedagogy theory that considers early triadic interactions as serving the primarily epistemic function of transferring relevant cultural knowledge about referent kinds. The speaker briefly summarized some of their recent studies on infants' interpretation of others' referential emotion manifestations in ostensive versus non-ostensive contexts that provide support for the pedagogy approach over the simulation-based mindreading models. Finally it was suggested that the theory of human pedagogy provides a novel – and empirically fruitful – theoretical perspective for significantly re-conceptualizing the nature of the early developmental processes that lead to a realistic understanding of others as having separate minds with differential knowledge contents.

After the fruitful preceding discussions the late afternoon session contained only two talks in order to give time for elongated general discussion after them. This session addressed the interference of genetic components of behaviour organising mechanisms with those based on learning (either individual or social) and on “deeply cognitive understanding”. To cohere these diverse issues Robert Gerlai, a professor of behavioural genetics and neuroscience chaired the session.

The first talk proposed a genome-wide analysis of brain expression differences in mammals and was presented by the geneticist, **Elena Jazin**. The idea that changes in regulatory regions have been a major motor for evolution was first proposed in 1971 by Britten and Davidson, and it was subsequently postulated that mutations in regulatory sequences account for most biological differences between species. These ideas have been reformulated recently, in light of vast information about the complete genome sequence of multiple organisms. Altered gene expression can operate faster than other known evolutionary mechanisms leading to species differentiation. This is most evident for species domesticated by humans, where strong selection for behavioural traits can trigger a rapid differentiation despite overall genome similarity. To search for expression differences that may have an impact on behaviour, the brain is the central organ to analyze. Measurements of expression differences in the brain can be performed on a genome-wide scale using microarrays. The combination of all the genes from an organism that are expressed in a tissue at a certain developmental phase is called a transcriptome and the method is called transcriptome analysis. One caveat is that genetic differences between the transcriptomes could be at least partially obscured

by the confounding effect of expression differences produced by changes in the living environment of the species compared. For example, the diets of humans and apes are very different, and dogs are fed regularly with variable food types and live mostly in controlled environments, while wolves have a diet restricted to availability of prey in the wild, and are subjected to long periods of fasting. This could have strong consequences in the hormonal balance and metabolism, with the possibility of strong effects in the transcriptome balance of each species. Several experimental strategies can be used to tackle this problem and disentangle genetic from environmental control of gene expression related to behaviour. Among them, artificial selection experiments in controlled environments, in combination with microarray analysis of expression differences in the brain, provide a powerful approach to pinpoint genetic differences in the transcriptome. In a Russian farm-fox experiment, silver foxes (a colour morph of the red fox, *Vulpes vulpes*) were selected for non-aggressive behaviour towards man for more than 40 generations. The result of this artificial selection experiment is a new breed of foxes that are similar to dogs in their friendliness and eagerness for human contact. The transcriptome analysis of docile versus regular foxes indicated that many genes are modified due to environmental causes and only a few gene expression differences were the result of genetic differences between the groups.

Another strategy to search for genetic differences in expression levels is the analysis of controlled pedigrees in which different related individuals present extreme differences in behavior. The speaker and her colleagues have used this kind of approach to search for transcriptome differences in narcoleptic dogs. Narcolepsy causes dramatic behavior alterations in both humans and dogs, with excessive sleepiness and cataplexy, a sudden loss of muscle tonus, triggered by emotional stimuli. Deficiencies in the hypocretin system are well established as the origin of the condition; both from studies in humans who lack hypocretin ligand (HCRT) and in dogs with a mutation in a hypocretin receptor (HCRTR2), but little is known about molecular alterations downstream of the hypocretin signals. By using microarray technology they have screened the expression of 3000 genes in the brains of Doberman dogs with a heritable form of narcolepsy (homozygotes for the canarc-1 [HCRTR-2-2] mutation) and their unaffected heterozygote siblings. In this model, all animals share the same genetic background as well as the environment. Two neuropeptide precursor molecules were identified, Tachykinin precursor 1 (TAC1) and Proenkephalin (PENK), that showed reduced expression in narcoleptic brains, particularly in the amygdala. Interestingly, it was previously shown that a single dose of amphetamine-like stimulants, that produce an increase in wakefulness in the dogs, also produce an increase in the expression of both TAC1 and PENK in mice. Thus, it seems plausible that these genes are intimately connected to the extensive daytime sleepiness not only in dogs, but also in other species, possibly including humans.

The speaker's research group has also designed a third experimental approach that not only allows for the search of genetic differences in the transcriptome, but it also permits the study of the mode of inheritance of such differences. They use a novel combination of traditional strain crosses to produce an F1 and two backcrosses, with behavioural analysis and quantitative brain gene expression profiling of all crosses generated. For these experiments, they used strains of mice selected for high production traits during 120 generations that showed marked differences in behavioural tests that measure anxiety-like traits. They identified a group of iron-related genes with altered expression patterns inherited in an additive manner, that correlate with anxiety-like behavioural

phenotypes. Interestingly, it seems as the same genes are modified in relationship to anxiety in mice and in the domesticated foxes described above. A challenge for the future is to design similar strategies to those described above for the study of traits related to social cognitive abilities.

In the second talk **Alexander Weir** talked about how tool use develops and manifests in New Caledonian crows giving a nice example of the interplay between inherited action patterns, individual, and social learning in 'complex' cognition. It had special importance since much of the workshop – just like the general practice of investigating comparative cognition – was devoted to identifying the cognitive processes underlying behaviour in mature, adult animals. This talk discussed something slightly different: the contribution of various factors to the development of complex behaviour in juveniles. While the factors that influence development are not necessarily related to those involved in deployment of the behaviour by adults, they can help shape our thinking about the latter.

New Caledonian crows are now well-known as proficient tool-makers and users in the wild, and show highly flexible, innovative problem-solving in captivity. Moreover, there is regional variation in the shape of some of the tools they make in the wild, which has been used to support claims of cumulative cultural transmission (Hunt & Gray 2003). How their tool using and making behaviour develops is therefore a critical question. There are several extreme possibilities (which are not mutually exclusive): (1) it could result from a set of genetically determined rules, as most animal architecture is thought to (e.g. nests and spiders' webs); (2) juveniles may have an inherited tendency to manipulate physical objects at random, gradually converging onto proficient tool use by their own history of reinforcement; (3) it may develop because of particularly advanced 'reasoning' abilities, with individuals 'working out' how to solve problems using tools; or (4) the behaviour may be passed on through observation of other tool-using crows.

Research group of the speaker has investigated this by hand-raising four New Caledonian crows in isolation from adult conspecifics. Two were given regular demonstrations of tool use by a human foster parent, while two were kept completely naïve (but had an equal amount of contact with humans). All four were found to develop functional tool use at about the same age, and even made crude tools from Pandanus leaves (Kenward et al. 2005). Moreover, functional tool-use was preceded by relatively stereotyped 'precursor' behaviours (Kenward et al. in press), suggesting that tool use arises as a consequence of inherited species-typical action patterns, probably coupled with associative learning about their consequences. However, the two birds that received demonstrations of tool use handled and inserted twigs more often than the naïve subjects, while there was no difference in the frequency with which they handled or inserted other objects. In an object choice the two tutored subjects showed strong preferences for interacting with novel objects that had just been handled by humans, supporting the hypothesis that New Caledonian crows are sensitive to social inputs during development. These findings are consistent with a combination of hypotheses (1) and (2) above, but do not rule out the possibility that in the wild, social influence is important—particularly given that none of our hand-raised crows have to date developed the sophisticated tool manufacture shown by wild adults. Finally, what implications do these issues of development have for the cognition underlying the deployment of tool-oriented behaviour in mature crows? 'Innate' is often used as shorthand for 'non-cognitive', but in fact the existence of inherited predispositions in no way precludes the existence of understanding or reasoning in adults.

The morning session of the last day analysed social learning as a cognitive process and included talks about studies on different primate species and grey parrots applying very different approaches and methods. Moreover Gyorgy Gergely, the expert of social learning in human infants chaired the session.

The session began with a talk by **Ludwig Huber** who introduced new results of a detailed analysis of marmoset imitation in a manipulative task. Imitation is of psychological interest in part because it has cognitive implications for how organisms view the behaviour of others, relative to their own behaviour. There is now considerable evidence that not only humans, but also great apes, monkeys, rats and birds can imitate perceptually opaque behaviour. Motor imitation has been defined as copying by an observer of a novel feature of the body movement of a demonstrator (Heyes 2001). Copying may be viewed or defined at different levels of matching fidelity: a) using the same body part as the demonstrator (e.g., hand or mouth); b) performing the same type of action (e.g., pulling or pushing); c) creating an exact copy of the movement (tracing the movement trajectories, or the kinematics, or the dynamics of the action). Evidence for the first (Voelkl & Huber, 2000) and the second level (Bugnyar & Huber 1997; Heyes & Saggerson 2002) already exists, but – to the best of our knowledge – is absent for the third level. The talk presented the key findings of a recent study by Voelkl and Huber, in which they aimed at determining the copying fidelity of marmosets by applying highly controlled video recordings, sophisticated motion analysis and proper statistical methods. The main findings rest on the in-depth comparison of actions performed by the demonstrator, the observers and the non-observers.

In a previous experiment (Voelkl & Huber, 2000), one animal was trained to use a peculiar technique to open film canisters to obtain a mealworm: instead of opening the canisters by hand, as marmosets usually do, it was found using its mouth. In the novel study we tested the observers and the model again, and also 24 naïve animals (non-observers) in order to find out if the mouth openings performed by the observers are more similar to the model's openings than are those of the non-observers. Using the standardized close-up video recordings of the movements the head motion of the subjects was analyzed with a MATLAB routine by manually identifying and tracking the position of five morphological features (trace-points) in the face of the subject on a frame-to-frame basis. The movement analysis revealed that the variance in the movement parameters is larger in the non-observers than in the observers. Performing the action in the same kinematic detail may be the first evidence of such (quantified) high level of copying fidelity of the kinematics or the dynamics of the model's movements in non-human animals. The present findings may have important implications for the currently available theory of imitation. First, they seem not fitting well in either the associative sequence learning (ASL) model (Heyes, 2001) or active intermodal matching (AIM) model (Meltzoff, 2002). While the first holds that imitative capacity depends on learned perceptualmotor links, the second proposes that supra-modal coding allows a visual representation of an observed action, which contains information about 'organ relations', to be matched up with a pattern of motor activation that can produce the same action. It would be difficult to give an account of the conditions of learning (ASL) or the selective environment (AIM) that could give rise to imitation at this level of specificity.

Finally, The speaker addressed the problems for the now very popular assumption of a role of mirror neurons for imitation for explaining these findings (Rizzolatti et al., 2001). It has been assumed that the mirror neuron system of ventral premotor cortex may provide a matching between the observed and the



executed action and, subsequently, can trigger the motor programs necessary for repeating the observed actions (Ferrari et al., 2006). But is the mirror neuron system capable of contributing in the formation of a motor representation of the lid-opening action in such detail? Without pre-existing (learned) motor representations imitation by automatic activation of them seems impossible. For instance, Calvo-Merino et al.'s (2005) finding suggests that the mirror system is better activated by actions that one understands and that one has already learned. And a number of observations (e.g., Umiltà et al., 2001; Kohler et al., 2002) strongly suggest that mirror neurons represent general aspects of actions such as the goal or its consequences rather than some other more elementary property of the movements (e.g., specific motor commands, muscle activity, movement direction). Assuming that mirror neurons code the goal of an action and not the movements to achieve it, which is the traditional assumption in the literature, could the goal of the model's action (retrieving mealworms) determine the exact movements to achieve it? So we are left with a number of unresolved issues and open questions – the speaker concluded. What determines the level of granularity at which actions are coded and identified? For instance, is the opening of the film canister represented in terms of the abstract type “biting into and then levering of the lid”, or is it represented in terms of the concrete token, the specific kinematic pattern by which the head moves in the act of levering? Can these findings be interpreted as indicating automatic control of behaviour and attributed to unconscious priming mechanisms?

**Marina Vancatova's** talk presented extraordinary results on social learning in primates and grey parrots. Both anthropoid primates and grey parrots are known as social animals with relatively high learning abilities. Ability of learning of quite complicated behavioural patterns from other individuals of the same social unit is quite important for their survival. These processes are influenced by several factors. The age of the individual, or more precisely the ontogenetic degree of the brain development, is one of the most important factors. Her experiments with young chimpanzees with approaching of a distant object (bite most usually) have shown that there is an evident relation among manipulation abilities and brain development in chimpanzee youngsters. Chimpanzees are able of active tool using and manipulation as late as in two years of age and they were able to make a more complicated tool in age of 40 months only. A hierarchic status of the trainer plays an important role. The transfer of certain abilities is realised mostly from mother to children. However, mothers do not take active part in learning in certain cases. The child imitates mother trying to act similarly like the mother. This is very probably the case of way of tool use at artificial termite nest by chimpanzees in Chester Zoo. While they more frequently prefer to use right hand during most types of manipulation activities they strongly prefer left hand during tool activities at the artificial termite nest. Furthermore, there is an evident process of social learning that stimulates youngsters to use left hand during termite-nest tool activities. The social status has appeared as very important factor in the case of “non-mother” trainer. It was found in this experiment with capuchin monkeys that studied individuals imitated tool behaviour of an alpha male in using of tool to obtain a newborn rat as a bite. Similarly, an experiment with picture making with great apes have shown the adult females started their spontaneous drawing after alpha male or at least with toleration of this behaviour by alpha male. Motivation was also found to play an important role. Capuchin monkeys could be motivated by newborn rats more than by usual fruits because it is well known that this monkey species hunts for small animals in natural conditions. Similarly in grey parrots many types of food or social motivations was used during learning experiments. In captivity not

only intragroup learning but also cross-species learning plays an important role. There are many examples both in grey parrots with their speech and behavioural pattern imitation but namely in great apes that are in daily contact with the keepers, some of them were even part of a keeper family or keeper societies. So they overtook many human habits and abilities. It should also be mentioned that some features of great ape tool activities could be *de facto* an imitation or simulation of similar human behaviour like cleaning of windows in captive orang-utans. In grey parrots one important factor influencing the quality of social learning is whether the individual was born in the wild and came to the laboratory as an adult or it has been captive born raised by a human individual. In this study the wild born parrot remembered only words used by another captive born parrot. All words that the wild born parrot used, she learned later than the captive born parrot. It is largely probable that the wild born parrot learned her words from the captive born parrot. Because the parrot repeated mainly two words learned from one human male trainer, it is likely that in learning there other specific factors (personal traits) play a more important role than the factor of trainer sex. The reason for this may be the fact, that the wild born parrot prefers sounds heard from another parrot than sounds heard from humans. Another factor is time for which the parrot knows its trainer - there is probably some time, for which the parrot must know its trainer. The parrot must learn better from this trainer. The process of learning runs by various ways, most usually by the method of trial and error, emulation and an imitation. The process of imitation is relatively frequent in great apes but we have also found two examples of imitation in capuchins and hamadryas baboon.

Now **Elisabetta Visalberghi** presented a comparative analysis on social influences on monkeys' feeding behaviour.

Finally **Zsófia Virányi** tried to direct the participants' attention to one of the several hidden assumptions of the experimental investigation of animal cognition and addressed the question of the possible influences of the relationship between humans and captive animals, and of the presence of humans in the experiments. Human beings are the most general components of the behavioural tasks applied in the study of comparative cognition. They are usually present as more or less passive observers whom we assume not to influence the animals' behaviour whereas in other cases they act as social partners of the subjects and the animals' reactions toward their behaviour is the subject of investigation. Though little we know (and little we ask) about the human-animal relationship implied in these situations the use of different practices is unavoidable ranging from habituation of wild-living animals to humans following them on the field to hand-raising them in a human environment. Despite explaining animal behaviour from a cognitive point of view is mainly about examining interpretations based on learning processes the animals' detailed rearing history and its possible effects on their performance in cognitive tasks are rarely reported. An exception is the discussion elaborated around the enculturation hypothesis (Call and Tomasello 1996) which tries to explain why human-reared apes outperform their laboratory-reared conspecifics in imitation, object-choice and some other cognitive tasks.

It is interesting to notice that the question whether members of the same species raised with different human influence show different cognitive performance is not directly in line with the evolutionary approach of comparative cognition. Basic aim of the field is to define the cognitive abilities of each species determined by genetic inheritance and experiences of its members in the species-typical environment that does not include human rearers. However even from this evolutionary point of view investigation of the effects of human rearing may be

relevant in finding the genetic differences between domestic species and their wild living relatives (and one might consider also chimpanzees and humans like this). As an alternative aim these comparisons may inform us about characteristics of human cognition and social behaviour in an indirect way through its influences on animal performance. Further on in accordance with the enculturation hypothesis human raised individuals may be promising subjects in those lines of research that try to determine limits of a species' capabilities via finding outstanding individuals with extraordinary skills. Nevertheless because of the aforementioned practical reasons we need to take these questions into consideration, and must not disregard that differences in cognitive performance of various species may result also from their different experiences with humans and other elements of human environment.

Several possible mechanisms have been proposed through which alteration of experiences with human environment may influence the subjects' performance in cognitive tasks. In great apes human rearing have been proposed to result in developing the understanding of others' behaviour intentionally (Call and Tomasello 1996). In a revised version of the theory (Tomasello and Call 2004) growing up with humans is assumed to stimulate apes to acquire a different set of social skills than their wild conspecifics after experiencing that humans "control their world totally and interact with them in ways that other apes do not". In Suddendorf and Whiten (2001)'s view however "what human enculturation may be doing is mimicking the natural social environment of wild apes in important aspects, allowing the individual to develop to its full capacity" and differences compared to captive chimpanzees reared in other ways can be attributed to the negative effects of meagre captive conditions. Bering (2004)'s apprenticeship hypothesis proposes that through their experiences enculturated apes become especially attuned to the actions of humans on objects and associate them with effective problem-solving. The observation, however, that human-reared chimpanzees spend more time engaged in the experimenter's actions than mother-reared chimpanzees and are less distracted by other things in the environment (Carpenter et al. 1995) may result also from their being less stressed. Human rearing most often includes increased exposure not only to humans but also novel objects and various situations which in turn leads to reduced startling effect of the elements of the test situation. This effect of human handling has been shown in several species by behavioural and physiological examinations (e.g. Barnett et al. 1994). Reduced stress may influence not only the attentional capacities of the animals but also the motivational value of the reward offered in the test situation. In a study comparing maternally and human raised wolves (Frank et al. 1989) it was also proposed that beyond the food reward purely engaging in social interaction with the experimenter might have different motivational value for the two groups based on their different relationship formed during the raising process. In accordance with the above hypotheses obviously human raising does not necessarily influence cognition directly but through emotional, motivational processes. Interconnection between these systems are far not understood enough, and that of effects of human rearing is only the fields where investigating it would be essential.

How great impact of differential rearing history can be on behaviour of the same species and despite of it how imprecise we are in reporting it will be shown on the case study of wolf hand raising. Canids are good examples to learn about the effects of human rearing because (1) there were several attempts and methods to raise them in captivity, (2) in their case human rearing has a theoretical relevance from the comparative point of view if we want to learn about the

genetically inherited capabilities of the domestic dog, and because (3) comparing the results of socialization in various canine species living in different social structures in the wild shows us that basis of the correct interspecies comparisons must be not the identical method of human rearing but its identical effects. Which to measure running controls is needed with the following preconditions: (1) the situation need to include all aspects of the test situation the reaction to which may be influenced by the socialization procedures (novel location, absence of group mates, presence of humans and equipments, etc.), (2) all species under comparison need to be involved, and (3) all of them need to show similar performance.

The final session was especially unifying in the sense that two philosophers draw connections between cognition and physiology. Relying on his neurophysiologic background Nathan J. Emery was requested to chair this session.

Firstly **Pierre Jacob** talked about whether and how mirror neurons can contribute to human social cognition, more specifically to theory of mind. One of the most remarkable contributions of cognitive neuroscience in the past fifteen years or so has been the discovery of so-called "mirror neurons" (MNs) in the pre-motor cortex of macaque monkeys and the subsequent discovery of a "mirror system" in the human brain. MNs are sensorimotor neurons that fire both when an animal is executing some transitive hand or mouth actions directed towards a target and when the animal is observing a conspecific (or an experimenter) perform the same kind of actions. The question is: what is (or what are) the main function(s) of MNs? The activity of MNs has been alleged to underlie such cognitive capacities as imitation learning (Rizzolatti, Fogassi and Gallese, 2001; Rizzolatti and Craighero, 2004), mindreading (Gallese and Goldman, 1998), and even language understanding (Rizzolatti and Arbib, 1998). Of these two, the talk concentrated on mindreading. Roughly speaking, the reasoning that led Gallese and Goldman (1998) to the view that a basic function of MNs is to underlie mindreading involves the following three steps. (1) The activity of MNs is taken to be a replicative or resonance mechanism in the following sense: the firing of MNs in an observer's brain is held to resonate with or match the firing of MNs in the agent's brain. (2) By duplicating the activity of MNs in an agent's brain, the activity of MNs in an observer's brain is supposed to constitute an automatic mental simulation (or rehearsal) of the agent's observed movements: the activity of MNs in the observer's brain is alleged to enable the observer to match the agent's observed movements onto her own motor repertoire (without executing the movements in question). (3) By performing a mental simulation of the agent's observed movements, the activity of MNs is expected to enable the observer to recognize (or understand) the agent's action or even to represent and thereby understand his or her intention (or goal). Since representing an agent's intention is unquestionably part of third-person mindreading, it turns out that one fundamental function of MNs is to underlie mindreading. As the above reconstruction makes clear, the reasoning for the view that the activity of MNs underlies mindreading borrows concepts from the simulation approach to mindreading. Conversely, it might be argued - and it has been argued - that the discovery of MNs vindicates the simulation approach to mindreading to the extent that it shows the existence of mechanisms of neural simulation in the primate brain enabling an observer to make sense of an agent's action on the basis of the former's perception of the latter's movements.

The speaker agreed that if the activity of MNs in an observer's brain did generate a representation of an agent's intention, then MNs would indeed make a

contribution to mindreading. However, he thought that two of the steps leading to the conclusion that the activity of MNs generates a representation of an agent's intention are open to doubt. For the sake of argument, he accepted assumption (2) that by replicating the activity of MNs in an agent's brain, the activity of MNs in an observer's brain constitutes a mental simulation (or rehearsal) of the agent's observed movements. But first, it is, he thought, highly questionable whether (3) by mentally rehearsing an agent's observed movements, an observer could represent (and thereby come to understand) the agent's underlying intention. Secondly, some recent empirical evidence casts doubt on the assumption (1) that the activity of MNs is a replicative (or resonance) mechanism. The new evidence from Fogassi et al. (2005) and Iacoboni et al. (2005) suggests that the activity of MNs is not a resonance (or a replicative) process but a predictive process.

Arguing against the view that the activity of MNs underlies mindreading by virtue of representing an agent's goal (or intention), the speaker provided an alternative answer to the question: what is the function of MNs? Representing an agent's action involves at least two complementary parts: representing the agent's goal and representing the motor command that will generate the motor sequence by means of which the agent achieves her goal. He argued that the activity of MNs contributes to the latter, not to the former. Furthermore, whereas an agent's intention (which is the cause of her motor act) can only be retrodicted from the perception of her motor act, the motor command that generates her next move can be predicted. Thus, he argued that the activity of MNs is predictive, not retrodictive. In a nutshell, whereas MNs have been alleged to compute a representation of an agent's intention from a prior representation of the agent's motor command in accordance with a forward internal model of action, following the suggestion of Csibra (2005), the speaker was arguing that MNs compute a representation of an agent's motor command from a prior representation of the agent's intention in accordance with an inverse internal model of action. He further suggested that the representation of an agent's goal (or intention) derives from the purely perceptual activity of the STS (which, unlike area F5 of the monkey premotor cortex or IPL) has no motor properties. Denying that the function of MNs is to represent an agent's intention is denying that their function is to underlie (third-person) mindreading. No doubt (third-person) mindreading is central to human social cognition, which may involve e.g., the ability to classify one's conspecifics on the basis of their professions, ethnic groups, and so on. The former, however, does not exhaust the latter. So if, as it was argued, it turns out that the function of MNs is not to underlie the representation of an agent's intention but rather to predict the motor command that will generate her next move, the activity of MNs may still be relevant to human social cognition.

Finally **Gyorgy Kampis** made a challenging proposal and encouraged all researchers working on fields related to comparative cognition to "database the mind" based on the complex physiological correlates of various mental states. Higher cognitive states (such as those involving consciousness or intentionality) are not observable directly and are studied via their correlates. A typical study of intentionality uses behavioural correlates and a typical study of consciousness uses neural correlates. For instance, researchers study choice behaviour, or EEG records. It is striking that the two kinds of approaches are seldom seen in a common methodological context. Together they offer themselves for a synthesis which may result in a new, powerful, and unified method. Cognitive states are complex physiological states of the whole organism and the suggested method utilizes this systemic, or organismic, perspective. Behavioural or neural correlates

typically are singular correlates: they are based on the pre-selected choice of a single, or a few but virtually independent phenotype variables. This method is prone to avoidable errors. In a methodological study informed from examples the speaker criticized the frequent use of singular correlates as methodologically deficient and one-sided. It is hard to see any gain in this practice, other than cost and labor efficiency. On the other hand, the idea to study multiple correlates in a systematic way is all too obvious, nevertheless underdeveloped. A complex correlate is a set of mutually independent physiological and phenotypic variables that together necessarily and regularly correlate with a specific cognitive state. The use of some multiple correlates, such as the monitoring of heart rate or the level of stress hormones together with a behavioural response (in intentionality studies or pain experiments, respectively) exists but not sufficiently widespread, and signifies a significant step towards the search for truly complex correlates. An example for the latter is in sneezing: in both humans and other animals the reflex of the *Medulla* evokes a complex set of responses correlated with one specific cognitive state (the “feeling” of sternutation). Monitoring a sufficient number of these correlates gives a statistically significant degree of certainty from their cross-correlations and co-variances, especially across species. “Study one thing at a time” is a methodological tenet with strong historical roots but in the light of an organismic and evolutionary perspective it becomes obsolete.

In the second part of the talk the theory was further developed using a “brute force” approach informed from systems biology. It is natural to locate the search for complex correlates in a more encompassing framework which facilitates transparent data handling already widespread in comparative studies in other fields. There are several important initiatives such as the Virtual Physiological Human project of the EC or the Neuroinformatics project as introduced by Steven H. Koslow (i.e. “Databasing the Brain”). Both offer large-scale, uniform analysis, storage and retrieval systems for mass information related to metabolic pathways (the “Physiome Project”) or neuroscience data, respectively. A significant amount of work goes into the definition of problem-specific conceptual frameworks such as “ontologies” that support the formation of large uniform databases via experimental datamining and knowledge acquisition techniques. Ideally, a similar (cross-species) integrated database of mind-related data on complex correlates for comparative studies should be established. This task becomes somewhat more realistic by the fact that in most cases the experimental data set can be nevertheless kept low dimensional by heuristics.

Each session was ended with a lively and provoking discussion, and the embedded structure of the **discussions** was finally justified by referring back to previous talks and earlier discussion several times. During course of the entire workshop the discussions considered mainly theoretically essential questions, which was probably due to the scientific questionnaire sent out before the workshop and keeping it up to date as the workshop proceeded in order to provide a constant general framework.

There were some starting points that seemed to be accepted by all participants and to help formulate this general framework for the investigation of cognition across species.

1. In order to unify the field the study of behavioural mechanisms need to be integrated into a functional and evolutionary framework.

2. Developing a meaningful comparative social cognition research agenda requires a clear understanding of both the evolutionary history and the developmental constraints of the behaviour being studied.
3. There are basic – but often unconscious – assumptions implied in comparative studies about the interrelations between cognition and motivation, emotions, social relations for instance which need to be revealed and systematically investigated.
4. The main problem is how to use functional behavioural definitions as a basis for experimental investigations when looking for behavioural mechanisms or the environmental effects on behaviour in different species. One possibility would be to make formal comparisons between species if general facets of social life present in most social species can be found. Obviously, however, there are often no common aspects to social life in different species, so the main question to answer is what kind of specific interactions, observed in only a limited number of species, can be functionally described as reflecting the same level of cognitive complexity?

On other points, however, there was less agreement. Among others the following topics were discussed extensively during the workshop.

1. At present in the field of comparative cognition it seems to be more urgent to define the various levels and kinds of cognition than to define cognition itself.
2. Probably the hottest attempt in present comparative social cognition is differentiating between mentalisation and associative learning processes. There is no general agreement whether and with which experimental methods it can be achieved. The various other intermediate possibilities should be defined and clearly explained.
3. Beyond the attempts of differentiating between the above two explanations the role of genetic predispositions should be considered more closely, and the questions of specificity and context-dependency of certain skills should be examined more thoroughly.
4. Behavioural similarities between species do not warrant assuming mechanistic similarities behind. For “real” comparisons between species knowledge is needed of the evolutionary history of the species and the individual history of the subjects.
5. Though the dual origins of the study of comparative cognition clearly come from ethology and psychology it is surprisingly not clear what researchers mean by these two approaches within the present field.
6. The integration of the individual and the group level information processing is needed, and finding the appropriate methods is probably one of the greatest challenge for the field at present.
7. The interconnection between cognitive performance and social relationships should be paid more attention and investigated more thoroughly. The results available have to be handled with caution from this point of view.
8. In species comparisons it would be essential to determine whether a certain similarity is to be considered as homology or analogy especially when it comes to modelling human characteristics with non-human animals’ features. We have assumptions about the origins of similarities across species often without justification.
9. Which is the mechanism of behaviour: cognitive background or neurophysiologic processes? How much can knowledge of the later one support that of the former one?
10. The term ‘intelligence’ should be reserved to describe individual characteristics.

We believe that all participants were influenced in their opinions about these questions and that their views began to converge. Their interest in these debates and discussions was shown by their willingness for further cooperation.

### **3. OUTCOMES OF THE ESF EXPLORATORY WORKSHOP AND ITS CONTRIBUTION TO FUTURE COMPARATIVE SOCIAL COGNITION**

The workshop was a highly successful event. The unique aspect of the workshop was bringing together experts of diverse disciplines in the frame of a small workshop with intensive and direct discussion between participants. The fields represented ranged from behavioural and cognitive science and developmental psychology to artificial intelligence/robotics, veterinary sciences, animal welfare and neuroscience, genetics or philosophy, which is rarely seen even in big conferences. In this case, however, experts of all disciplines attended each others' talks and participated in joint discussions, facing the challenge of finding and using a common language and building bridges between different the approaches in the study of the mind. The personal interactions required the transparency of comparative social cognition.

Over the course of the three days, we were able to achieve all of the goals the ESF Exploratory Workshops were designed to accomplish. The workshop was highly interdisciplinary and international. Due in large part to the prestige of the ESF, we were able to recruit top scientists willing to invest in cooperation across disciplines to take part in this event.

The small and intimate nature of the workshop afforded substantial opportunities for discussion and debate between participants. In doing so, this workshop afforded a new outlook on many issues associated with the study of the human and non-human animal mind. A unique feature of the workshop was keeping the discussions continuously in a general framework including scientists from across fields whose work followed different motivation, approaches and methodologies with which to focus around a common theme.

During these discussions several problems, difficulties and challenges of the field were defined explicitly (see above) requiring further coordinated activities from the experts of the related fields. Finally participants of the workshop decided to continue with well-defined cooperative activities in four subfields. To work for further agreements on the required approach, methodology, interpretation and application in these subfields participants of the workshop formed four groups with members from different disciplines.

1. What is special about social cognition?
2. Association learning and mentalisation (and what might be between)
3. Social relationship and cognition
4. Social learning and the ways of cultural knowledge transmission

However the participants of the workshop decided to continue also with more general further joint activities for which an ESF Research Networking Programme would be a perfect form. Accordingly we prepared an application (CompCog) for the 2006 October call of ESF Research Networking Programme by joining forces of the recognized laboratories represented by the workshop participants with other prestigious researchers from related fields who were invited to join this application.

Our hope is that the workshop was the first step in a European level collaboration of various – biological and applied – fields of the study of the mind



such as animal cognition, developmental psychology, philosophy, genetics, neurobiology, robotics, veterinary sciences and animal welfare. The establishment of common knowledge of comparative social cognition could facilitate the development of better animal model to understand the functioning of the mind including genetic and psychopharmacological models for the medical sciences, offer novel insights for designing of robotic systems which could provide testing beds for these ideas.

#### 4. FINAL PROGRAMME

##### Wednesday 4 October 2006

###### *Arrival*

- 18.00-18.15 **Greetings and introduction**  
Ádám Miklósi and Zsófia Virányi (Convenors)
- 18.15-18.30 **Presentation of the European Science Foundation (ESF)**  
Zoltán Varga (Standing Committee for Life, Earth and Environmental Sciences) and Gün Semin (Standing Committee for the Social Sciences)
- 18.30-20.00 **Introductory round table discussion**  
Introduction of participants, discussion on the definition and levels/kinds of cognition and on emerging problems of the field, and preparation of the meeting.

##### Thursday 5 October 2006

###### **Conceptual issues of social cognition**

*Four 30-min talks followed by 15-min discussions*

- 09:00-10:40 **Nathan Emery**: What's so special about social cognition? (40')  
**Josep Call**: Chimpanzee social cognition
- 10:40-11:00 *Coffee break*
- 11:00-12:30 **Robert Gerlai**: Autistic zebrafish? Can we model complex human social problems with lower order vertebrates?  
**Ádám Miklósi**: Comparative social cognition: Aims and means
- 12:30-13:00 General discussion
- 13:00-14:30 *Lunch*

###### **Comparative or species-specific social cognition?**

*Four 30-min talks followed by 15-min discussions*

- 14:30-16:00 **Zhanna Reznikova**: Cognitive specialisation and social learning in social insects: the formula of happiness in animal communities  
**Paola Valsecchi**: The role of dog-human relationship and attachment in the study of social cognition
- 16:00-16:30 *Coffee break*

16:30-18:00 **Suzanne Held:** A view from the trough: some issues in social cognition research from a pig perspective

**Juliane Kaminski:** Knowing what others see and have seen: Reconstructing the evolution of social cognition

18:00-18:30 General discussion

Departure 19:00 *Dinner in csárda Oak*

## Friday 6 October 2006

### Communication with and perception of companions

*Three 30-min talks followed by 15-min discussions*

9:00-10:30 **Márta Gácsi:** Old problems and new data (and this way, new problems) concerning the comprehension of human gestural cues

**Daniel Mills:** Gaze bias as a novel method of investigating social cognition in domestic dogs

10:30-11:00 *Coffee break*

11:00-11:45 **Shaun Lawson:** Beyond technophilia - social relationships with computers and other machines

11:45-12:15 General discussion

12:15-13:30 *Lunch*

### Do we need “theory of mind”?

*Three 30-min talks followed by 15-min discussions*

13:30-15:45 **Nicola S. Clayton:** Counter espionage by food-caching Western scrub-jays (*Aphelocoma californica*): Implications for social cognition

**Thomas Bugnyar:** Knowledge attribution in food-caching ravens?

**Gergely György:** Beyond imitative learning: Mechanisms of cultural transmission in human and non-human animal cultures

15:45-16:15 General discussion

16:15-16:45 *Coffee break*

### Genes, learning and “understanding”

*Two 30-min talks followed by 15-min discussions*

16:45-18:15 **Elena Jazin:** Genome-wide analysis of brain expression differences in mammals

**Alex Weir:** The interplay between inherited action patterns, individual, and social learning in the development of 'complex' cognition in New Caledonian crows

18:15-19:30 General discussion

## Saturday 7 October 2006

### **Social learning as a cognitive process**

*Four 30-min talks followed by 15-min discussions*

9:00-10:30 **Ludwig Huber:** Imitation in marmosets: precise copying of movements

**Marina Vancatova:** Social learning in primates and grey parrots

10:30-11:00 *Coffee break*

11:00-12:30 **Elisabetta Visalberghi:** Social influences on feeding behaviour: a comparative analysis

**Zsófia Virányi:** One thing we all make decision but rarely talk about: Humans' presence in studies on animal cognition

12:30-13:00 General discussion

13:00-14:30 *Lunch*

### **Cognition and physiology as reflected by philosophy**

*Two 30-min talks followed by 15-min discussions*

14:30-16:00 **Pierre Jacob:** What do mirroring processes contribute to human social cognition?

**György Kampis:** Searching for complex correlates

16:00-16:30 General discussion

16:30-17:00 *Coffee break*

17:00-19:00 **Overall discussion: conclusions and planning future cooperation**

Departure 19:00 *Dinner and wine tasting at the Vanyolai Family Cellar*

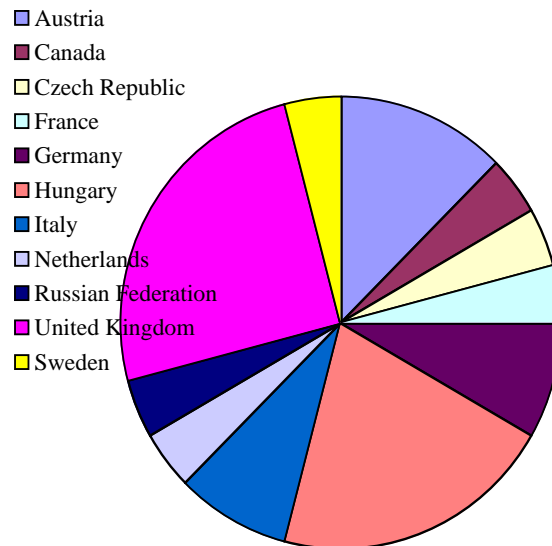
## Sunday 8 October 2006

*Departure*

## 5. STATISTICAL INFORMATION ON PARTICIPANTS

Country of origin:

Country	No of participants
Austria	3
Canada	1
Czech Republic	1
France	1
Germany	2
Hungary	5
Italy	2
Netherlands	1
Russian Federation	1
United Kingdom	6
Sweden	1
Sum	24



Age distribution:

Stage of career	No of participants
Senior	18
Junior	6
Sum	24

Sex distribution:

Sex	No of participants
Female	10
Male	14
Sum	24

## 6. FINAL LIST OF PARTICIPANTS

### Convenors

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