Final Report: Expert Meeting Social Neuroscience of Imitation

On May 25th-26th of 2006, the ESF funded Expert Meeting on the social neuroscience of imitation was held in Castell d'Emporda, near Girona, Spain. It was attended by 11 researchers from 5 European countries.

The reason for organizing the Expert Meeting was twofold: First, by bringing together a diverse and complimentary group of researchers interested in imitation, we set the ambition to spur integrative and innovative new research ventures. The participants have backgrounds in neuroscience, cognitive psychology, neurophysiology, social psychology and developmental psychology

Second, the Expert Meeting was a first step towards integrating the enormous potential currently present in separate European countries with respect to state-of-the-art research on intersubjective phenomena such as imitation. These phenomena are extremely well suited for inter-disciplinary approaches and several incidental collaborations have already been set up. However, without a good platform, we will not be able to fully profit from the people and resources available in Europe at this moment.

The program consisted of talks and research-based smaller group meetings and was designed to stimulate concrete, new research projects to be conducted in 2006 and 2007. The meeting was very successful and at this moment several projects have been started and some projects are at the stage of writing the article. The next goal is to find the best suited format to institutionalize this initiative.

We thank the ESCON and ESF very much for sponsoring this extraordinary meeting!

Scientific Content

Overview: The meeting was designed to lead to concrete collaborative research efforts. In order to achieve this, every participant had the opportunity to present data on recent experiments. As importantly, however, a major part of the time was devoted to smaller gatherings in which new plans were developed in a multi-disciplinary team (2, 3 or 4 participants). Composition of these groups was flexible.

Below are first the program, then the abstracts of the presentations and finally the outcomes of the discussions leading to future plans.

Program:

ESCON EXPERT MEETING CASTELL D'EMPORDA

THURSDAY 25th

Breakfast … until 09:00

09-15 – 11:00 Session 1	Bekkering & Bird
11:00 – 11:45 Coffee break	
11:45 – 13:30 Session 2	Gergely & Aarts
13:30 – 15:00 Lunch	
15:15 – 17:00 Session 3	Fadiga & Craighero
17:00 – 17:45 coffee break	
17:45 – 19:30 Free-style	Smaller groups
20:30 Dinner	

FRIDAY 26th

Breakfast … until 09:00

09-15 – 11:00 Session 4	Van Baaren & Dijksterhuis
11:00 – 11:45 Coffee break	
11:45 – 13:30 Session 5	Van Leeuwen & Brass
13:30 – 15:00 Lunch	
15:15 – 17:00 Free-style	Smaller groups
17:00 – 17:45 coffee break	
17:45 – 19:30 Future	Plenary
20:30 Dinner	

Presentation Abstracts:

Ap Dijksterhuis: I would like to argue that imitation, and especially imitation of complex behavioral patterns, constitutes the "social glue" that makes us successful social animals. In various parts of the chapter I will stress the social benefits of imitation. Furthermore, I will argue that imitation is of such importance because it can be conceived of as default social behavior. Imitation is not something we only occasionally engage in. Instead, we usually imitate--automatically--and not doing it is the exception. In the next section, I briefly review some findings that show that people imitate the observable behavior of others and I emphasize the evidence for the social benefits of imitation. A more elaborate discussion of the imitation of entire behavioral patterns follows. Finally, I review some evidence showing that when people do not engage in imitation, the moderators causing this state of "nonimitation" can be tied directly to the social function of imitation.

Harold Bekkering: Interest in the recognition and imitation of actions has grown considerably in the last ten years among neuroscientists. Here, we want to investigate the relationship between the orienting of attention of the model and the imitator. Specifically, the question is raised if we are particularly able (fast and accurate) to orient our attention in line with the gaze of a model? To study this question gaze cues were contrasted with the more symbolic arrow cues. In the gaze condition a schematic drawing of a face had depicted two eyes looking left, right or in the middle. In the arrow-pointing condition arrowheads pointing to the left, right or in the middle, replaced the eyes. A detection target appeared at three different stimulus onset asynchrony (SOA) intervals of 100 ms, 300 ms, or 1000 ms to the left or to the right of the face. In the first experiment participants were told the direction of cues to be non-predictive with respect to target location. Cueing effects (faster response times when eyes or arrowheads are directed toward than away from the target) were apparent already after 100 ms SOA and the reaction time costs and benefits were similar for eyes and arrowheads. This experiment provides insight concerning the role of biological and social stimuli in orienting attention and the volitional nature of gaze and arrow pointing. More direct links with neurocognitive mechanisms of orienting attention in imitation are discussed.

Geoffrey Bird: Can observational learning be effector dependent? In 3 experiments, observers watched a model respond to a 6-item unique sequence in a serial reaction time task. Their sequence knowledge was then compared with that of controls who had performed an unrelated task or observed a model responding to random targets. Observational learning was indicated when the introduction of a new sequence was associated with more reaction time elevation in observers than in controls. The authors found evidence of observational learning only when observers used the finger movement sequence that they observed during training, not when they responded at the same sequence of locations using different digits. Free generation and recognition tests also detected observational learning. These results imply that observational learning can be both explicit and effector dependent.

Gyorgy Gergely: By the end of their first year human infants start to exhibit a number of species-unique social cognitive competences (such as social referencing, imitative learning of novel means, or proto-declarative pointing) that involve triadic interactions in ostensive communicative cuing contexts. The currently dominant interpretation of these early social-cognitive phenomena assumes that their primary function is to serve *social motives* (such as intersubjective sharing of mental states). In this talk I shall contrast this view with an alternative interpretation based on the theory of human 'pedagogy' (Csibra & Gergely, 2006; Gergely & Csibra, 2005, 2006) which assumes that ostensively cued triadic interactions serve primarily the *epistemic* function of transferring new and relevant cultural knowledge about referents to infants. The theory argues that others' referential manifestations during triadic interactions are typically framed by specific types of *ostensive-communicative cues* for which infants show early sensitivity and preference. These include eye-contact, contingent turn-taking reactivity, the prosodic intonation

pattern of motherese, and addressing infants by their own name. Such ostensive cues trigger in infants the interpretation that the other exhibits a communicative intention addressed to them to manifest new and relevant information for them to fast learn about the referent. It is hypothesized that ostensive cues can act as an 'interpretation switch' directing infants to construe others' referential knowledge manifestations as pedagogical 'teaching' events. I shall review recent evidence from studies of relevance-guided selective imitative learning and of infants' differential interpretation of others' referential emotion expressions during the second year that provide convergent empirical support for the hypothesized interpretation-modulating role of ostensive cuing in early infancy.

Henk Aarts: Three experiments examined whether the mere priming of potential action effects enhances peoples feeling of causing these effects when they occur. In a computer task, participants and the computer independently
moved a rapidly moving square on a display. Participants had to press a key, thereby stopping the movement. However, the participant or the computer could have caused the square to stop on the observed position, and accordingly, the stopped position of the square could be conceived of as the potential effect resulting from participants_ action of pressing the stop key. The location of this position was primed or not just before participants had to stop the movement. Results showed that (subliminal as well as supraliminal) priming of the position enhanced experienced authorship of stopping the square. Additional experimentation demonstrated that this priming of agency was not mediated by the goal or intention to produce the effect.

Luciano Fadiga: Single neuron recordings in monkeys and transcranial magnetic stimulation (TMS) and brain imaging studies in humans have been extensively employed by several groups to investigate how actions are represented in the brain. In the last decade new evidence is growing in favour of an additional, more cognitive, role played by motor and premotor centers. Clear motor activation is evident when one simply imagines a motor act and it has been shown that during other's action observation, a temporo-parietal-frontal circuit, becomes active in the observer's brain. Which is the function of this 'high-level' motor involvement? Why, to understand how other individuals act our brain looks inside its own motor representations? Is this motor involvement functional to perception or does represent a mere epiphenomenon? In the first part of my talk I will review the neurophysiology of action representation in monkey premotor cortex, then I will describe some recent TMS experiments on action perception in humans. In the second part of my talk I will show some TMS results demonstrating that not only observing actions but also 'listening to action' enhances the excitability of the motor cortex. During passive listening of speech, normal subjects 'motorically resonate' by internally re-acting the listened words. If on one side these data give support to Liberman's motor theory of speech perception, on the other side they suggest that "visuo-motor" and "acoustic-motor" matching systems may represent two particular aspects of a more general mechanism, used by the brain to map sensory information on its own motor repertoire.

Marcel Brass: In the last decade empirical evidence has cumulated that the observation and execution of actions share common functional and neural mechanisms (Brass & Heyes, 2005, Rizzolatti & Craighero, 2004). More specifically, it has been argued that the observation of an action leads to an activation of a motor representation in the observer (Iacoboni et al., 1999). Such shared representations were assumed to form the basis for action understanding and more general social cognitive abilities.
However, if this assumption holds true, the question arises how we can distinguish between internally generated and externally triggered motor representations? In other words, why don't we confuse intentionally activated motor representations with externally triggered motor representations? In a series of experiments we have addressed this question by investigating the neural mechanisms involved in the inhibition of imitative behaviour. We could show that in accordance with the shared representation hypothesis (Decety & Sommerville, 2003) the inhibition of imitative actions requires

functional mechanisms that allow us to distinguish self from other (Brass, Derrfuss & von Cramon, 2005). Furthermore, we could show that not only the observed action is mapped onto a motor representation but also environmental constraints.
In the second part of the talk we report an experiment in which we directly investigated the question which brain areas are involved in action understanding. Currently, there are two opposing views on action understanding. The mirror neuron approach suggests that action understanding is achieved by motor simulation of the observed action in the mirror system. The alternative approach suggests that functional mechanisms such as mentalizing are involved in action understanding. In the present study we investigated the neural mechanisms underlying action understanding by adapting a paradigm pioneered in developmental psychology. In this paradigm participants observe an actor executing a very common action in an unusual way (i.e. operating a light switch with the knee). In one condition the hands of the actor are occupied with very heavy folders, making the unusually action very plausible (hands occupied condition). In some trials, however, the hands of the actor are not occupied, which makes the action very implausible (hands free condition). Finally, we also included a condition where the hands were implausibly occupied. The crucial contrast for investigating action understanding is the contrast of the hands free condition (implausible action) and the hands occupied condition (plausible action). This contrast revealed brain activation in the superior temporal sulcus (STS),the temporo-parietal junction (TPJ) and the anterior fronto-median cortex. Since all three regions have no mirror properties, our data seem to support the view that action understanding in terms of its reasons is primarily mediated by functional mechanisms other than motor simulation.

Rick van Baaren: People often nonconsciously imitate other people and imitation has positive consequences for the interaction. We argue that imitation not only has consequences for the way in which an imitated person feels towards the imitator, but that imitation also changes the way in which the imitated person feels towards other people in general. In two studies participants were unobtrusively imitated by a confederate and the effects on interpersonal closeness were measured. Experiment 1 showed that imitated participants feel closer to non-specified other people in general compared to non-imitated participants. Experiment 2 replicated this result using a seating distance measure. Together, these studies reveal that imitation has consequences that go beyond the dyad. Now the challenge is to look for a system, which can explain this implicit imitation recognition.

Matthijs van Leeuwen: If perceptual and bodily states are closely linked and if perceiving actions automatically leads to corresponding activation in one's own motor-system, then why don't we imitate all the time? There is evidence suggesting that Executive Functioning (EF) plays a moderating role in inhibiting overt imitation (e.g. Luria, 1966). In an experiment we tested this hypothesis. 48 participants received either a high or low Working Memory (WM) load and were instructed to respond to either a finger cue or spatial cue with a finger movement. Results indicate that occupying WM facilitates reaction times to finger cues while slowing responses to spatial cues. The findings suggest that imitation is a dominant response and EF is needed to inhibit the spontaneous tendency to imitate.

Discussion

Already at the pre-conference diner on May 24th, all participants indicated that the most fruitful approach would be to set up experiments instead of theoretical discussions. We all agreed that the composition of the group constituted a unique opportunity to create a real social-cognitive neuroscience group. Based on the presentations by each participant, we would select two or three topics that need a multi-disciplinary research effort. In the smaller group sessions, both afternoons, we set the goal to think of concrete series of experiments to be run in different countries.

We came up with three topics that have many unanswered questions and would uniquely benefit from our teamwork:

-Consequences of imitation why and how? The basic idea here is that we know a lot about the underlying processes of imitation and we also know a lot about the social consequences of imitation. It is a complete mystery, however, how the positive consequences of imitation come about. We do not know how our brain recognizes (unconsciously) that we are being imitated and we do not know how our motivational and affective system come to react the way they do.

We start with two experiments to investigate these questions.

1-Amsterdam. An fMRI study in which participants take on either a happy, neutral or sad face. Then, either congruent or incongruent facial expressions are flashed on the screen in the scanner. Congruent combinations should lead to reward system activation.

This study has already been run (19 subjects) and the data are very promising. Congruent combinations activated the insula (indicating positive affect), whereas incongruent combinations activated Broca's area and the ACC, indicating expectancy violation and conflict.

This experiment is currently being followed up by a study manipulating expectancy through 1- a likeability manipulation and 1- a implicit stereotypes.

2-Leipzig. An fMRI study in which participants observe an interaction between two people filmed from the perspective of one of the interaction partners. The behavior of this person (arm- and leg movements) are imitated or not. We expect similar results as in Study 1. To be run in March 2007 (Gent University, due to job change by Marcel Brass).

-Imitation and Inhibition: How do we inhibit spontaneous imitation? The basic idea is that there is a contradiction between the literature on imitation and what we see when look at people in real life: We seem to be wired to imitate and the last 16 years of research show almost exclusively how automatic and innate imitation is, yet we do not imitate each other all the time in reality. We hypothesize that Executive Control is required to control inhibition, and when EC is absent or loaded, imitation will be facilitated. 3 experiments will start to investigate this paradox.

1-London. This experiment will look at the effects of alcohol consumption on spontaneous imitation. Using the finger-task by Brass, we will test whether people who have drunk several glasses of beer have more difficulty inhibiting spontaneous imitation of finger movements. This study will be run in March 2007

2-Nijmegen. In previous work it was found that EC load facilitates imitation. In the present study the hypothesis is tested that under EC load, there will be less "room" to monitor one's behaviour and hence, there will be less Error Related Negativity in an EEG signal when one makes an imitative error in the Brass task. We expect a smaller N400 signal during EC-load compared to when all resources are available.

3-Leipzig. Given that imitation is by definition social, a load condition in which Theory of Mind capacity is loaded should have a detrimental effect on the inhibition of imitation. In this study, either EC will be loaded by an WM-load, a ToM load, or no load during a real life interaction with a confederate. We expect most spontaneous imitation in the ToM condition, second in the WM condition and least in the control condition.

-Monkey see, Monkey do? The basic idea is that the present literature on mirror neurons and spontaneous imitation overlooks extensive work by primatology and ethology showing that in may cases apes and people behave in manners related to dominance/hierarchy/status. In these cases it is unlikely that imitation would be the appropriate answer, because that would lead to conflict. The present studies will look for the neural correlates of automatic complementarity.

1-Ferrara. This TMS experiment investigates whether there is a resonance response or a inhibitory response in our leg muscles when we see a person stand up (indicating dominance). Based on the mirror literature, one would expect resonance, whereas inhibition would be more ecologically valid. Using a TMS/EMG set up, we measure the pre-motor response in the tiabilis anterior when a participant sees a person stand up, move his arms or not move.

This study has already been run (n = 9) and the data look very promising. There is a strong inhibitory response in 8 out of 9 participants, whereas only 1 shows resonance. The next studies will investigate complementary muscles (e.g. breast/chess expand/constrict) in order to see whether it really is complementarity (perception of a leads to deactivation of a and activation of b) or only inhibition (perception of a leads to deactivation of a). Another study will pre-select dominant and submissive people and see whether dominance moderates resonance-complementarity.

2-Nijmegen. This fMRI study examines whether being imitated is more positive for affiliation related behaviours, and whether being complemented is expected and valued for dominance related behaviours. In the scanner, subjects will take on several postures (related to dominance or affiliation) and are either imitated or complemented by the person (an avatar, in fact) on the screen they watch. We expect Broca's and ACC both when they are not imitated on the affiliation dimension and when they are imitated on the dominance dimension.

Future:
We are very optimistic about the future of this group. Our concrete, multidisciplinary, experimental focussed approach has already resulted in interesting and publishable data. There are more experiments on the way and new ones have already been developed. Furthermore, several intra-group visits have taken place.
We have extensively discussed the future of the group and which format would be best to ensure that we will continue to build this new field in the future. The consensus at the end of this discussion was that we will start (and indeed have started) our collaborative research from our own research funding and we will apply for research grants within our own countries. The main reason for this approach is that international grants (projects or network funding) often take a long time and come with many formalities and other non-content related work that would slow down the momentum we have at this moment. We are convinced that the best way to ensure a rapid and solid future is an approach in which, each time, smaller (2 main applicants) research teams are created. Local grants will be applied for, but hopefully new initiatives by the ESF or Human Frontier Science will de developed, which make it easier to support and institutionalize a network like ours.