Harold Bekkering - selected references

1 Hunnius, S. & Bekkering, H. (2014). What are you doing? How active and observational experience shape infants' action understanding. *Philos.Trans.R.Soc.Lond B Biol.Sci., 369,* 20130490.
Notes: From early in life, infants watch other people's actions. How do young infants come to make sense of actions they observe? Here, we review empirical findings on the development of action understanding in infancy. Based on this review, we argue that active action experience is crucial for infants' developing action understanding. When infants execute actions, they form associations between motor acts and the sensory consequences of these acts. When infants subsequently observe these actions in others, they can use their motor system to predict the outcome of the ongoing actions. Also, infants come to an understanding of others' actions through the repeated observation of actions and the effects associated with them. In their daily lives, infants have plenty of opportunities to form associations between observed events and learn about statistical regularities of others' behaviours. We argue that based on these two forms of experience-active action experience and observational experience-infants gradually develop more complex action understanding capabilities

2 Paulus, M., Hunnius, S., & Bekkering, H. (2013). Neurocognitive mechanisms underlying social learning in infancy: infants' neural processing of the effects of others' actions. *Social Cognitive and Affective Neuroscience, 8,* 774-779.
Notes: Social transmission of knowledge is one of the reasons for human evolutionary success, and it has been suggested that already human infants possess eminent social learning abilities. However, nothing is known about the neurocognitive mechanisms that subserve infants' acquisition of novel action knowledge through the observation of other people's actions and their consequences in the physical world. In an electroencephalogram study on social learning in infancy, we demonstrate that 9-month-old infants represent the environmental effects of others' actions in their own motor system, although they never achieved these effects themselves before. The results provide first insights into the neurocognitive basis of human infants' unique ability for social learning of novel action knowledge

3 Ondobaka, S., Newman-Norlund, R. D., de Lange, F. P., & Bekkering, H. (2013). Action recognition depends on observer's level of action control and social personality traits. *PLoS.ONE., 8,* e81392.
Notes: Humans recognize both the movement (physical) goals and action (conceptual) goals of individuals with whom they are interacting. Here, we assessed whether spontaneous recognition of others' goals depends on whether the observers control their own behavior at the movement or action level. We also examined the relationship between individual differences in empathy and ASD-like traits, and the processing of other individual's movement and action goals that are known to be encoded in the "mirroring"

and "mentalizing" brain networks. In order to address these questions, we used a computer-based card paradigm that made it possible to independently manipulate movement and action congruency of observed and executed actions. In separate blocks, participants were instructed to select either the right or left card (movement-control condition) or the higher or lower card (action-control condition), while we manipulated action- and movement-congruency of both actors' goals. An action-congruency effect was present in all conditions and the size of this effect was significantly correlated with self-reported empathy and ASD-like traits. In contrast, movement-congruency effects were only present in the movement-control block and were strongly dependent on action-congruency. These results illustrate that spontaneous recognition of others' behavior depends on the control scheme that is currently adopted by the observer. The findings suggest that deficits in action recognition are related to abnormal synthesis of perceived movements and prior conceptual knowledge that are associated with activations in the "mirroring" and "mentalizing" cortical networks

4 de Bruijn, E. R., Mars, R. B., Bekkering, H., & Coles, M. G. (2012). Your mistake is my mistake . . . or is it? Behavioural adjustments following own and observed actions in cooperative and competitive contexts. *Q.J.Exp.Psychol.(Hove), 65,* 317-325.
Notes: A social speeded choice-reaction-time task was used to study adaptive behaviours following own and observed actions (errors and correct responses) in cooperative and competitive contexts. After making an erroneous response, the appropriate remedial action to avoid future errors in speeded reaction tasks is to slow down. Consistent with previous results, people indeed slow down following their own errors. Importantly, people who slow down most following own errors also slow down following observed errors in a cooperative situation. In a competitive context, a different pattern was found. People accelerated after errors from their opponent. The current findings demonstrate that the social context determines the way people respond to the errors of others, indicating that the neural systems that control remedial actions are highly flexible. These systems may underlie social adaptive behaviour, enabling people to respond flexibly to other people's actions in a wide variety of social contexts

5 Uithol, S., van, R., I, Bekkering, H., & Haselager, P. (2011). Understanding motor resonance. *Social neuroscience, 6,* 388-397.
Notes: The discovery of mirror neurons in monkeys, and the finding of motor activity during action observation in humans are generally regarded to support motor theories of action understanding. These theories take motor resonance to be essential in the understanding of observed actions and the inference of action goals. However, the notions of "resonance," "action understanding," and "action goal" appear to be used ambiguously in the literature. A survey of the literature on mirror neurons and motor resonance yields two different interpretations of the term "resonance," three different interpretations of action

understanding, and again three different interpretations of what the goal of an action is. This entails that, unless it is specified what interpretation is used, the meaning of any statement about the relation between these concepts can differ to a great extent. By discussing an experiment we will show that more precise definitions and use of the concepts will allow for better assessments of motor theories of action understanding and hence a more fruitful scientific debate. Lastly, we will provide an example of how the discussed experimental setup could be adapted to test other interpretations of the concepts

6 Paulus, M., Hunnius, S., Vissers, M., & Bekkering, H. (2011). Imitation in infancy: rational or motor resonance? *Child Development, 82,* 1047-1057.
Notes: The present study investigates the contribution of 2 mechanisms to imitation in infancy. The principle of rational action suggests that infants normatively evaluate the efficiency of observed actions. In contrast, it has been proposed that motor resonance (i.e., the mapping of others' actions onto one's own motor repertoire) plays a central role in imitation. This study tested 14-month-old infants (n = 95) in 5 conditions and manipulated the extent to which the observed actions could be matched onto the infants' own motor repertoire as well as whether the observed behavior appeared to be efficient. The results suggest that motor resonance plays a more central role in imitation in infancy than does a rational evaluation of the observed action

7 Newman-Norlund, R. D., Noordzij, M. L., Meulenbroek, R. G., & Bekkering, H. (2007). Exploring the brain basis of joint action: co-ordination of actions, goals and intentions. *Social neuroscience, 2,* 48-65.
Notes: Humans are frequently confronted with goal-directed tasks that can not be accomplished alone, or that benefit from co-operation with other agents. The relatively new field of social cognitive neuroscience seeks to characterize functional neuroanatomical systems either specifically or preferentially engaged during such joint-action tasks. Based on neuroimaging experiments conducted on critical components of joint action, the current paper outlines the functional network upon which joint action is hypothesized to be dependant. This network includes brain areas likely to be involved in interpersonal co-ordination at the action, goal, and intentional levels. Experiments focusing specifically on joint-action situations similar to those encountered in real life are required to further specify this model

8 Newman-Norlund, R. D., van Schie, H. T., van Zuijlen, A. M., & Bekkering, H. (2007). The mirror neuron system is more active during complementary compared with imitative action. *Nature Neuroscience, 10,* 817-818.
We assessed the role of the human mirror neuron system (MNS) in complementary actions using functional magnetic resonance imaging while participants prepared to execute imitative or complementary actions. The BOLD signal in the right inferior frontal gyrus and bilateral inferior parietal lobes was greater during preparation of complementary than during imitative actions, suggesting that the MNS may be essential in dynamically coupling

action observation to action execution

9 Bekkering, H., Brass, M., Woschina, S., & Jacobs, A. M. (2005). Goal-directed imitation in patients with ideomotor apraxia. *Cognitive Neuropsychology, 22,* 419-432.
Notes: H. Bekkering, University of Nijmegen, NICI, PO Box 9104, 6500 HE Nijmegen
The present study compared imitation performance in patients with ideomotor apraxia (IMA), eight right hemispheric-damaged patients, and eight control participants without neurological damage in three experiments. Experiment 1 confirmed in the Goldenberg test that IMA patients were particularly impaired in hand gestures and combined finger and hand gestures, but not in the imitation of finger gestures, compared to the other two groups. Experiment 2, however, demonstrated that finger selection is not per se preserved in imitative behaviour in patients with IMA. Experiment 3 confirmed this finding in an experiment under visual control. Together, the results add evidence to the idea that imitation should be viewed from a goal-directed rather than a body-mapping perspective, and that highest priority is given to more distal aspects of imitation as reaching for the correct object, rather than the means used to achieve the goal of a modelled action.

10 Rumiati, R. I. & Bekkering, H. (2003). To imitate or not to imitate? How the brain can do it, that is the question! *Brain and Cognition, 53,* 479-482.
Notes: Programme in Neuroscience, Scuola Internazionale Superiore di Studi Avanzati, Trieste, Italy. rumiati@sissa.it
In this paper the authors discuss the most prominent views addressing the issue of how we imitate actions. It is argued that the existing theories lay along a continuum, with the direct mapping approach at one end (Butterworth, 1990; Gray, Neisser, Shapiro, & Kouns, 1991) the Active Intermodal Matching approach (Melzoff & Moore, 1997) in the middle, and the goal-directed theory (Bekkering, Wohlshager, & Gattis, 2000) and the dual route theory (Rumiati & Tessari, 2002) at the opposite end. Interestingly the latter views can account for behaviors that cannot be explained by invoking the direct mapping or the Active Intermodal Matching approach

11 Bekkering, H. (2002). Imitation: Common mechanisms in the observation and execution of finger and mouth movements. In A.N.Meltzoff & W. Prinz (Eds.), *The imitative mind: Development, evolution, and brain bases* (1 ed., pp. 163-181). Cambridge: Cambridge University Press.

12 Bekkering, H., Wohlschlager, A., & Gattis, M. (2000). Imitation of gestures in children is goal-directed. *Quarterly Journal of Experimental Psychology A,Human Experimental Psychology, 53,* 153-164.
Notes: Department of Cognition and Action, Max-Planck Institute for Psychological Research, Munich, Germany. bekkering@mpipf-muenchen.mpg.de ; ABSTRACT: The view that the motor program activated

during imitation is organized by goals was investigated by asking pre- school children to imitate a set of hand gestures of varying complexity that were made by an experimenter sitting in front of them. In Experiments 1 and 3, children reached for the correct object (one of their own ears or one of two dots on a table) but preferred to use the ipsilateral hand. This ipsilateral preference was not observed when hand movements were made to only one ear (Experiment 2), or when movements were directed at space rather than physical objects (Experiment 3). The results are consistent with the notion that imitation is guided by goals and provide insights about how these goals are organized 200006