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Selective Imitation in One-Year-Olds: How a Model's Characteristics Influence Imitation

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Dekan: Prof. Dr. Matthias M. Müller

Gutachter: Prof. Dr. Wolfgang Prinz
Prof. Dr. Michael Tomasello
Prof. Dr. Gisa Aschersleben

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1 General Introduction

Imagine a pair of twins named Talea and Tim who live with their parents in the city of Leipzig. Both infants have just started to crawl. During their exploration of the house, they regularly encounter a constant source of frustration: doors that are left ajar. Driven by the motivation to explore the entire house, the twins come up with two different strategies to deal with them. Tim chooses to randomly explore the door: He is already able to grasp objects, so he begins to grasp the door and soon discovers that it is not fixed but flexible. Through trial and error he learns that pulling the door makes the gap wider so that he can pass through. Talea in contrast, carefully observes the manner in which her parents manipulate the door, and in doing so notices that by pulling the door with one's hand the gap can be widened. Equipped with this knowledge, she approaches the door and successfully opens it on the first attempt.

From the first few days of their lives, infants are continuously developing their skills. In general, there are two routes by which infants may acquire them: infants can either develop a skill based on their existing abilities (like Tim), or infants can use information provided by others (like Talea). Based on their existing abilities, infants are able to develop a new skill by trial and error learning. More precisely, consequences of a random behaviour that satisfy one's needs strengthen this particular behaviour and consequences that do not satisfy one's needs weaken this particular behaviour. This however is a stressful method of learning: it is time consuming, and it might even be dangerous, should the infant encounter a potentially harmful situation. Whilst humans are able to mentally simulate their approach before they physically tackle a problem (Bischof, 2008; Hegarty, 2004), mental simulation requires a maximum of ingeniousness and the success of this strategy is therefore unpredictable. Trial and error learning and mental simulation are therefore restricted by an individual's existing abilities.

By contrast, humans are also capable of using information provided by others. First, one can learn from others by drawing attention to the location of an action (local enhancement, Thorpe, 1956) as well as to the object of an action (stimulus enhancement, Spence, 1937). In this case, the object or the location attracts one's attention independently of the specific behaviour that is directed towards the object or location. As a result, humans can learn about the relevant objects or locations without paying attention to what the demonstrator does with the object. Second, one may learn from others by focussing on the external results of a conspecific's action (emulation, Tomasello, 1999. However, one could use one's own means in order to reproduce the same result. As a consequence, a conspecific serves rather as a catalyst in revealing a formally unknown state of affairs in the environment. Humans have an effective third strategy to rapidly acquire novel skills: they are able to imitate conspecifics (Carpenter & Call, in press; Tomasello, 1999; Tomasello, Carpenter, Call, Behne, & Moll, 2005). Imitation can be defined as not only involving the reproduction of the external result, but also the internal goal and the means of a demonstrator. Throughout the history of psychology, generations of researchers have been fascinated by the ability to imitate. Some researchers have focussed on the mechanism of imitation and various theories have been proposed to describe this mechanism. In some accounts imitation is understood to be learnt associations between sensory and motor representations (Heyes, 2001). In other accounts it is suggested that there is a direct and innate link between action perception and action production (Rizzolatti & Buccino, 2005). An intermediate position has also been proposed that assumes that action perception and action production share cognitive representations (Meltzoff & Moore, 1997; Prinz, 1990, 1997). Other researchers have focussed on the function of imitation. Piaget (1962), for example, regarded imitation as at the heart of the puzzlement reaction produced in infants when a model is observed performing novel acts. As a result, infants' cognitive capacity expands via imitation. Uzgiris (1981) raised an important issue concerning imitation; she suggested that imitative acts also entail a non-verbal element when communicating with a model. More recently, Tomasello (1999) highlighted the importance of imitation for cultural transmission and Csibra and Gergely (2006) stressed selectivity in infant imitation and its role in human pedagogy.

The initial purpose of this dissertation was to explore the notion of selective imitation. I asked how selective imitation in infants is influenced by a model's characteristics such as age and reliability, and the completeness and familiarity of an action.

The introduction is divided into three sections. In the first part I will integrate this question into the broader context of imitation, namely, a definition and then theories about the development of imitation. In the second part, I will review the existing literature exploring factors that modulate infant imitation, such as a demonstrator's goal, age, and reliability, the consequences of a demonstrator's behaviour as well as the medium of demonstration (live vs. televised). In the third part, I will give an outline of the experiments that we conducted in order to investigate this question.

1.1 Infant Imitation

1.1.1 Definitions of Imitation

The notion of imitation can claim an intuitive approach like many other psychological concepts do. Maybe because of the amalgamation of individual folk psychology and scientific general psychology, definitions of imitation abound already, but none are universally accepted. Accordingly, I only selected prototypical definitions of imitation.

The first paradigmatic definition comes from Byrne and Russon (1998). They defined imitation as the acquiring of a *novel* behaviour after having observed a demonstrator performing that same behaviour. They argued that the novelty of the behaviour is an essential part of the definition of imitation. That is, if the behaviour already exists in the action repertoire of the imitator, other explanations for the reproduction of the model's and observer's behaviour remain plausible (such as stimulus and local enhancement or emulation). Along similar lines, Meltzoff (1988b) defines a novel action according six different criteria: 1) it has never been perceived, 2) it has never been performed 3) although possibly performed, it is not a well-practiced action, 4) it has not been imitated, 5) the action has not been related to a particular object, 6) it almost never occurs spontaneously during free play. As criteria 1-5 are largely beyond the investigator's knowledge, Meltzoff emphasized the importance of criterion 6 in the study of infant imitation. To limit the definition to the criterion of point 6 weakens the concept of novelty because spontaneous occurrence of a so-called novel action is often low or absent in a laboratory setting. However, evidence that under particular conditions infants do not perform a certain behaviour should not be taken as evidence that they in general never do so. Stressing the importance of novelty might therefore prove a helpful approach when it comes to designing laboratory experiments for it may help distinguish imitation from other forms of learning mechanisms. However, humans in their natural environment might also imitate familiar behaviour as well (Zentall, 2005).

A second definition of imitation was raised by Tomasello (1999). He states that imitation displays the infant's understanding of a model's intention. He emphasised that imitation involves not only the reproduction of an external result, but also of a model's internal goal and the chosen means to achieve this goal. Want and Harris (2002) specified this definition with respect to the understanding of the affordances of an object. Gibson (1979) claimed that humans perceive possibilities for actions and he labelled these possibilities "action affordances". Want and Harris (2002) divided the concept of imitation into two subcategories: blind and insightful imitation. Blind imitation meets all the criteria set out by Tomasello (1999), however, blind imitators are ignorant of the affordances of an object. Insightful imitation is conceived of as copying the result, means, and goal of an action and additionally learning about affordances.

A third notion of imitation involves copying body movements. It is disputed as to whether only copying the body movements of another individual without copying the result or goal represents imitation. Tomasello (1996) defined imitation as an object-directed action involving the copying of the movements of an individual's body parts. However, he defined the sole copying of body movements as mimicry. Tomasello et al. (2005) suggest that mimicry, in contrast to imitation, may be blind to the intentions or goals of the model and is therefore to be regarded as qualitatively different from imitation. Byrne and Russon (1998) also proposed two different forms of imitation: program level and action level imitation. Program level imitation is the ability to extract the hierarchical structure of an action sequence and imitate this overall strategy. However, analogous to mimicry, action level imitation is defined as a detailed imitation of another's motor behaviour. In addition, Jones (2007) showed in her cross sectional study that mimicry is not based upon a single specialized mechanism. She suggested that the development of mimicry is instead based on different components such as motor, cognitive, and social knowledge, as well as motivation, which have their own complex developmental course. By contrast, Meltzoff & Moore (1977; 1989; 1997) suggested that the ability to copy body movements is already present in newborns. According to them, copying body movements in general is based on a supramodal representation of movements that infants observe in others and movements that infants perform themselves. Therefore, newborns' ability to copy body movements is not qualitatively different from copying a conspecific's goal and the chosen means to achieve that goal.

Because there is no universally accepted definition of the term "imitation", I will use it as a label for an infant's reproduction of the demonstrated behaviour. I will discuss the benefits and problems of this account along with the implications for future experiments (see chapter 6.5). The overall aim of this dissertation was to investigate infants' selectivity in reproducing a behaviour over a variety of models, based on variables such as a model's age.

1.1.2 Theories on the Development of Infant Imitation

Piaget's (1962) theory had a profound impact on our understanding of the development of imitation. He proposed that infants develop their imitative abilities in six consecutive stages during their first two years of life. Stage 1 reflects the newborn's limited abilities, namely inborn reflexes that can be modulated by means of accommodation and assimilation. In Stage 2, the infant starts reproducing their own acts. This primary circular reaction allows also for the imitation of another's actions that are already in the infant's motor repertoire. In Stage 3, the so-called secondary circular reaction enables the infant to imitate observable actions and their effects coming from two different domains, e.g. touch and vision. The ability to reproduce an action is still limited by its own motor repertoire. Then, in Stage 4, these abilities are extended as the infant begins to copy the movements of body parts that they can only observe in others but not in themselves (e.g., the tongue). In Stage 5, the so-called tertiary circular function arises and enables the infant to imitate novel actions: that is, the infant is able to imitate novel methods in order to achieve a desired goal. Finally, in Stage 6, the infant is able to form representations that are different from their actual perception. This semiotic function enables the infant to memorise the perceived action and to defer its imitation to a later point in time.

Meltzoff and Moore ((1977) challenged Piaget's highly popular view of imitation. They showed that newborns appear to reproduce the oral gestures of an adult demonstrator. Meltzoff and Moore (1997) interpreted this neonatal imitation in terms of the infants having common representations for action perception and action production. According to their so-called Active Intermodal Mapping approach, the tendency to copy another's action is based on a common framework for representing the observation and execution of human movements (for a similar account, see Hommel Müsseler, Aschersleben, & Prinz 2001, and Prinz, 1997). More precisely, an innate equivalence detector unifies observation and execution of body movements via a supramodal form of representation. Accordingly, deviations between observed and executed body movements are detectable. Proprioceptive feedback then allows the matching of one's own movement to the observed movement. However, after three decades of research on neonatal imitation, there is still debate about the significance of neonatal imitation. Anisfeld (1979; 1996; 2005) has reviewed studies on neonatal imitation and has shown that the only consistent results seem to be those based upon tongue protrusion. Jones (1996; 2006) provided empirical evidence that one-month-olds' tongue protrusion is also an exploratory behaviour and that infants find a protruding tongue more interesting than an open mouth.

Despite inconclusive evidence for neonatal imitation, the case for a common representation of perceived and performed motor acts still stands, for common representations of action perception and production do not have to be present at birth, but instead might develop during infancy and childhood when a natural environment prevails. These common representations might also be based on associative sequence learning during infancy (Heyes, 2001). Heyes has suggested that infants might have to learn the connection between a sensory input and the matching motor output via acquired equivalence experiences, such as visual feedback, reflecting surfaces, and imitating carers. Based on this account, one may assume that once these connections are established in a bidirectional manner, they form the common representational system.

In contrast to those authors who stress the connection between action perception and action production, Tomasello et al. (2005) emphasised that infant imitation depends on an understanding of the intentional structure of actions. In their view, this understanding develops sequentially between birth and the age of 14 months. At around 6 months of age, infants understand that others are animate agents. That is, infants perceive actions as self-produced rather than as externally generated movements. Woodward's (1998) seminal study demonstrated six-month-olds' ability to understand others act animately. In her study, infants were habituated to an agent who consistently grasped one of two different objects placed always in the same location. After switching the location of the two objects, infants were found to look much longer at the agent who grasped the new object in the same location as compared to the agent who grasped the old object in the new location. Tomasello et al. (2005) argued that this behaviour does not reflect goal understanding as infants only need to be familiar with the actor's habits in familiar circumstances. By 9 months of age, infants begin to understand that other individuals act persistently according to their internal goal. Nine-month-olds are aware that other individuals see objects and that vision guides their evaluation as to whether the desired goal was achieved or not. In several looking time studies it has been shown that infants understand behaviour as a means to achieve an external result (Csibra, Bíró, Koós, & Gergely, 2003; Csibra, Gergely, Bíró, Koós, & Brockbank, 1999; Gergely, Nádasdy, Csibra, & Bíró, 1995). In Gergely et al.'s study (1995) infants were habituated to a large animated circle that repeatedly approached and contacted with another small circle by jumping over a barrier. When the obstacle was removed, infants dishabituated when the large circle performed the same familiar jumping approach, but they did not dishabituate when the large circle performed a new straightforward approach. Additionally, Behne, Carpenter, Call, and Tomasello (2005) provided evidence that infants are able to apply their understanding of goals in life-like situations. Infants from the age of 9 months onwards reacted with more frustration (e.g., by looking away or banging with their arms) if an experimenter was unwilling to hand over a toy compared to an experimenter who was unable to hand over a toy. Finally, at around 14 months of age, infants understand that another individual considers different action plans, chooses one of them, and commits to it in order to achieve a goal. Gergely, Bekkering, and Király (2002) presented 14-month-olds with an adult who illuminated a lamp using her forehead. In one condition (hands-free), she had no obvious reason not to use her hands because her hands were simply resting beside the lamp. In the other condition (hands-occupied), her hands were occupied by holding a blanket while she performed the unusual head action. Infants predominantly imitated the head touch in the hands-free condition but not in the hands-occupied condition, even if they had had their own hands-on experience that they could illuminate the lamp with their hands. Tomasello and colleagues (2005) interpreted this finding as evidence that infants had reflected on the reason for the adult's choice to use the head rather than the hands. In the hands-occupied condition, infants may have assumed that the adult was forced to use her head because her hands were occupied holding the blanket; as the infants were not themselves constrained, they chose to use the more straightforward method, their hands, to illuminate the lamp. In the hands-free condition, where infants imitated the head action, infants may have speculated that there was potentially a opaque reason for the novel action because the model's hands were theoretically able to operate the lamp. According to Tomasello et al. (2005), infants had understood that the demonstrator must have reflected rationally before choosing an action plan in order to achieve a desired goal. Note that recent studies on goal understanding and understanding of intentions have disputed Tomasello and colleagues' (2005) timetable. Some studies show that infants already understand that others are animate agents by the age of 5 months (Luo & Baillargeon, 2005), and that infants might develop an understanding of goals by 6.5 months (Csibra, 2008), and an understanding of intentions by 12 months of age (Schwier, van Maanen, Carpenter, & Tomasello, 2006). Although infants might develop each of these abilities earlier than suggested by Tomasello and colleagues (2005), there is no need to dispute the sequential development of each of the stages.

Tomasello et al.'s (2005) view contrasts with Gergely and Csibra's (2003) "principle of rational action": although Gergely and Csibra also stress the dependence of infant imitation on the understanding of actions, they take a non-mentalistic approach in explaining one-year-olds' ability to interpret actions. According to them, one-year-olds only interpret actions based on perceptually available aspects of reality and not based on internal states like goals and choice of action plans. The core assumption of the so-called *principle of rational action* is that infants interpret actions in terms of the most efficient means at an actor's disposal to achieve external results within the constraints of a situation. Now, if one applies this logic to the looking time studies cited above (Gergely et al., 1995) one arrives at a different interpretation. According to the authors, infants assumed that the large circle was a rational agent. If the large circle violated the principle of rational action, that is, if the dot made a detour to reach the small circle, infants reacted with surprise, resulting in longer looking times. By contrast, in the condition where the large circle behaved according to the principle of rational action, infants were not surprised and were consequently found to have shorter looking times.

Along these lines, it is not necessary to assume that in Gergely et al.'s (2002) version of the head touch task infants reflected on the demonstrator's plan of action when they observed her using her head to illuminate a lamp. They may simply have assumed that adults are rational agents and when they use a novel means to operate the lamp there might be an opaque benefit for this action as compared to the more straightforward hand action.

The debate between both accounts is still ongoing. However, in the light of growing evidence that one-year-olds have a basic understanding of false belief (Buttelmann, Carpenter, & Tomasello, 2008; Onishi & Baillargeon, 2005) a non-mentalistic re-interpretation of these results within Gergely and Csibra's (2003) framework does not seem to be correct. Despite the current debate as to whether these studies provide evidence for an early Theory of Mind (Perner & Ruffman, 2005), Gergely and Csibra (2003) limited their account to the interpretation of actions that do not involve fictional or counterfactual situations. They assumed that one-year-olds are not able to represent mental states. The debate about how imitation develops in infancy must serve as a reminder therefore to cautiously interpret infant studies, for although there is evidence that infants are able to sophistically imitate another person's behaviour, one must also consider simpler mechanisms of imitation that do not involve an understanding of mental states.

1.2 Beyond Development: Environmental Factors Modulating Infant Imitation

Piaget (1962) "consider[s] the pre-verbal imitation of the child as one of the manifestations of his intelligence. (…) Moreover, as we shall see, the connection between the stages of imitation and the six stages we found in the development of sensory-motor intelligence is so close that in the analysis which follows we shall use the same scale" (p. 5). For Piaget, infants' imitative performance in a specific situation is directly linked to their general ability to imitate. As shown above, a great proportion of the research on infant imitation in the past few decades has concentrated on investigating the mechanism of imitation or the developmental course of infant imitation. Additionally, it might be informative to focus on modulating factors that influence infant imitation. At least, three important factors have been identified and studied in the past. First, that infants' imitative behaviour is influenced by a model's goal during the performance of a target action. Second, that the consequences of the demonstrated behaviour influence the likelihood that infants imitate. Third, that model characteristics also have an effect on infant imitation. I shall now analyse the impact of each of these factors in detail.

1.2.1 A Model's Goal

Tomsello et al. (2005) defined an intention as the choice of a specific means to achieve a desired goal. As noted above, infants become able to infer another person's goal between 6 and 9 months of age. Nine-month-olds are able to distinguish between an actor that is unwilling to hand over a toy vs. an actor that is unable to do so (Behne et al., 2005). Moreover, already by 6 months, infants are able to infer the end-state of an uncompleted object-directed action (Daum, Prinz, & Aschersleben, 2008a). Note that in these studies, infants displayed their sensitivity to an agent's goal, not by re-enacting that goal, but by showing signs of frustration (Behne et al., 2005) or by a longer looking time towards the unexpected end-state (Daum, Prinz, & Aschersleben, 2008a). During the second year of life, infants start to use the information of another person's goal during his or her action for their own action control. Meltzoff (1995) investigated, via a behavioural re-enactment method, how infants react to an adult who tried, but failed, to perform an action: do they blindly copy the surface behaviour or do they re-enact what the adult intended to do? His study revealed that 18-month-old infants were able to re-enact the desired goal of a failed attempt. For example, infants separated a wooden dumbbell into two pieces when the demonstrator's hands had failed to do so, but instead had simply slipped off the dumbbell when they had attempted the action. Particularly noteworthy is the fact that infants did not replicate this behaviour when mechanic pincers demonstrated the same surface behaviour as the model. This study was one of the first examples to show that infants' re-enactment of an action is guided by another persons' goal. In subsequent studies in which analogous tasks were applied, it was shown that the ability to re-enact intended but unfulfilled goals is present in 15-month-olds but not in 12-month-olds (Bellagamba & Tomasello, 1999; Johnson, Booth, &

O'Hearn, 2001; Sanefuji, Hashiya, Itakura, & Ohgami, 2004). Legerstee and Markova (2008) recently reported that 10-month-olds are able to re-enact failed attempts. However, it remains unclear as to what extend this study is comparable to the study of Bellagamba and Tomasello (1999) where 12-month-olds were not able to re-enact failed attempts. Legerstee and Markova (2008) explained these diverging results with respects to differing task difficulties. However, both studies differed in at least one other respect. In Bellagamba and Tomasello's (1999) study infants' actions were either scored with 0 for not performing the target act, or with 1 for performing the target act. In Legerstee and Markova's (2008) study, infant responses were scored from 1 to 5, with only a score of 4 or 5 representing the target action. Legerstee and Markova only reported the mean score. Thus, it remains to some extent unclear as to which behaviour infants actually performed. Analogous to the looking time study conducted by Daum, Prinz, & Aschersleben (2008a), Hamlin, Hallinan, and Woodward (2008) reported that 7-month-olds selected one of two toys that had been the target of an experimenter's successful grasping or unfulfilled reach. In contrast, infants did not select the target toy any more often, if the experimenter pointed towards it or if she placed the back of her hand on the toy. Therefore, the infants' selectivity is not solely based on stimulus enhancement of the toy. Instead it shows that 7-month-olds are sensitive to a demonstrator's goal and that they actively reproduce this goal.

The interpretation that infants' imitative performance is guided by a demonstrator's goal has been recently challenged. In several studies it was reported that non-imitative mechanisms like emulation and stimulus enhancement could be responsible for the re-enactment in one-year-olds of the model's failed attempts (Huang & Charman, 2005; Huang, Heyes, & Charman, 2002, , Thompson & Russell, 2004). In contrast, Slaughter and Corbett (2007) showed that 18-month-olds (but not 12-month-olds) were more likely to imitate human models and Legerstee and Markova reported that for complete demonstrations of an action, 10-month-olds' imitation score was alike regardless of its being a human or non-human model. However, for failed attempts, the score was higher when a human model was used than a non-human model. The latter two studies argued against the assumption that stimulus enhancement is the prevalent mechanism at work in the failed attempt studies using Meltzoff's (1995) design. Additionally, Call, Carpenter, and Tomasello (2005) modulated the dumbbell used in

Meltzoff's (1995) study. They created a tube with a reward inside that could be opened in two ways: by removing the caps at both ends of the tube or by breaking the tube in the middle. After an experimenter modelled one of these two ways of receiving the reward, two-year-olds chose to copy the specific style of opening the tube. Thus, toddlers did not solely focus on the model's outcome but also on his actions. We can thus conclude that already at the age of 6 months infants are able to detect another person's goal. Infants, no later than 15 month of age, and perhaps already by 10 months, are able to modify their imitative performance based on the model's goal. However, non-imitative learning mechanisms such as stimulus enhancement and emulation might also play an additional role in the Meltzoff's (1995) behavioural re-enactment paradigm.

Consistent with studies using Meltzoff's (1995) paradigm where infants re-enacted a failed attempt, Carpenter, Akhtar, and Tomasello (1998) showed that 14- to 18-months-old infants are less likely to imitate actions that were performed accidently than those actions that were performed intentionally. Thus, infants do not blindly copy any behaviour they observe once they are able to imitate, but instead seem to be motivated to imitate actions that are performed intentionally.

As noted above, 14-month-olds are more likely to imitate a novel action (the head touch) when they infer that the model freely chooses to use this means (hands-free condition) compared to a situation where the model is forced to use this means due to situational constraints (hands-occupied condition, Gergely et al. 2002). Schwier et al. (2006) reported similar results for 12-month-olds using an analogous task. The authors of both studies concluded that infants around their first birthday interpret another individual's action in terms of its rationality. However, one could also infer that infants understand intentions as rational choices between different action plans.

In sum, there is evidence that infants as young as 6 months are sensitive to another person's goal. The notion of this early emergence of goal understanding stems from studies with low task demands in paradigms including looking time, behavioural signs of frustration, and copying of object choices. For re-enactment tasks that involve actions from one object to another object, there is evidence that infants around 15 months of age are able to infer a model's goal. For object-on-object actions, it is unclear whether model characteristics such as a model's age influences infants' capacity to detect a model's goal.

1.2.2 Consequences of Actions

Bandura (1977) analysed imitative behaviour in great detail. He identified four successive processes. First, he assumed that attention is necessary in order to learn. This process determines what is selectively observed in the stream of behaviour and what is extracted from such exposure. Second, he postulated a retention process that ensures that the learner represents the modelled action in their memory in symbolic form. These representations might be either verbal or imagined. Third, he assumed that the symbolic representation is converted into the appropriate action. The behavioural response is selected and organized at the cognitive level and partly depends on the availability of component skills. That is, if one component of the target behaviour is not stored in the individual's repertoire it has to be developed by repeated modelling and practice. Finally, Bandura distinguished between the acquisition and the performance of an observed behaviour. Not everything that is learned will be performed. The performance of learned behaviour depends not only on external reinforcement, but also on vicarious and self reinforcement. According to Bandura, these reinforcements modulate the individual's motivation to perform the acquired behaviour.

In a seminal study on imitative learning, Bandura (1965) showed that preschool children imitated aggressive behaviour more often when the model was reinforced for his aggressive behaviour than when he was punished for this behaviour. Vicarious reinforcement can be labelled as an environmental factor on the modelled action. Bandura suggested that vicarious reinforcement does not influence the acquisition of the observed behaviour; this kind of reinforcement rather modulates the motivation to perform a particular behaviour. Vicarious reinforcement is a sophisticated example of children's ability to account for the environmental consequences of the model's behaviour when they decide whether to imitate the observed behaviour or not.

In the previous example, vicarious reinforcement is mediated by a social agent who evaluates a model's behaviour. However, there are more direct environmental factors involved in infant imitation. Action effects that are determined by the action itself have a great impact on action control (e.g., a rattling noise that is produced by shaking a rattle). The importance of action goals for action selection and action planning has been highlighted by Prinz (1997). He assumed that actions are represented and controlled by their anticipated action effects. There is evidence that action effects do not only help infants to understand goal-directed actions (Jovanovic et al., 2007; Király, Jovanovic, Prinz, Aschersleben, & Gergely, 2003), but they also play an important role in imitation (Hauf, Elsner, & Aschersleben, 2004; Klein, Hauf, & Aschersleben, 2006). For example, infants observed that one step (i.e., either shaking a cylinder or returning a cylinder to a board) of a three-sequence action resulted in an interesting acoustic effect (Hauf et al., 2004; Klein et al., 2006). By 12 months of age, infants imitated those actions that resulted in an effect much faster than actions without an effect.

Consequences of behaviour that are provided either by social agents or by the behaviour itself influence the likelihood that children and infants copy the modelled behaviour. Therefore, one must cautiously consider this variable in studies on selective imitation in infancy.

1.2.3 A Model's Characteristics

Bandura was also one of the first developmental psychologists to investigate the impact of a model's characteristics on imitation in preschool children and elementary school children. For example, in a study by Bandura, Ross, and Ross (1963) it was reported that children imitated a model with higher social power more often than a model without social power. Subsequently, many further studies have investigated the impact of the model's characteristics on learning, including variables such as sex, age, and reliability.

1.2.3.1 A Model's Sex

Bandura, Ross and Ross (1961) showed that for verbal aggression, children were more likely to imitate the same-sex model than the opposite-sex model. Furthermore, model sex influences the acquisition of gender role behaviours. That is, if same-sex models played with toys that are typically labelled as "sex-inappropriate" (e.g., boys who played with a baby doll) children played with these toys more frequently than children who observed an opposite-sex model playing with the same toys (Kobasigawa, 1968; Wolf, 1973). However, this effect could not be found in a children's game with no traditional gender bias (Bandura & Kupers, 1964). Additionally, in two studies on children's cognitive learning (Schunk, Hanson, & Cox, 1987; Simon, Ditrichs, & Speckhart, 1975) a model's sex did not influence children's performance.

Children's tendency to take a model's sex into account is rooted in the ability to distinguish males and females. However, there is mixed evidence for this ability in infants. In a looking time study a preference for same-sex models was shown for both sexes (Kujawski & Bower, 1993), and in another looking time study this effect was reported for female but not male infants (Lewis & Brooks-Gunn, 1975). However, in a third looking time study no preferences for same-sex models were prevalent (Shirley & Campbell, 2000). To my knowledge, there is no infant imitation study that offers support for the notion that infants imitate same-sex models more often than opposite-sex models. Children develop the ability to identify male and female sex between 2 and 3 years of age (Etaugh, Grinnell, & Etaugh, 1989; Fagot & Leinbach, 1989). However, this capacity is not equivalent to a mature understanding of gender as an invariant category. Perloff (1982) reported that a preference for imitating same-sex models is modulated by the child's gender constancy, namely, their awareness that a person's sex cannot change. When given a choice between imitating a same-sex model performing a relatively unpleasant task and an opposite-sex model enacting a more pleasant behaviour, children that have already obtained gender constancy were more likely to indicate an imitative preference for the same-sex model than children without gender constancy.

To summarise, there is mixed evidence that infants are able to distinguish between males and females and there is no evidence that a model's sex consistently influences infant imitation. Research on preschoolers has shown that only children who have attained gender constancy opted for imitating same-sex models. Therefore, the ability to differentiate between males and females may not suffice to selectively imitate same-sex models.

1.2.3.2 A Model's Age

In general, young infants encounter three different age groups: peers, older children, and adults. Each of these groups might attract infant attention for different reasons, and the preference for each of these age groups may provide a specific benefit for the infant as outlined below.

Infants might exhibit a preference for peers for two reasons. First, as Sanefuji, Ohgami, and Hashiya (2006a) have pointed out, peers have babyish characteristics and they are the most similar conspecifics. Lorenz (1943) has systematically reported that babies across different species share babyish characteristics such as relatively big eyes and forehead arch. Both of these elements are considered to be elicitors of nurturing behaviour, and it has been suggested that the positive affect elicited by the sight of these infantile characteristics is already present in infancy (McCall & Kennedy, 1980). Second, Piaget (1962) suggested that peers are important for the child's cognitive development, because they share a similar worldview. Along these lines, Meltzoff (2005) suggested that infants perceive others as "like me": that is, infants understand others based on their understanding of their own behaviour. In terms of the motor repertoire and cognitive abilities, peers are the most similar from conspecifics of various ages to the test infant. Therefore, the increased similarity between an infant and a peer might attract the infant's attention.

On the contrary, older children might also elicit infants' attention. Vygotsky (1978) highlighted the importance of knowledgeable others for the child's development. He speculated about a zone of proximal development, which is created by others when they share knowledge with young children. The zone of proximal development is defined as "*the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers"* (*Vygotsky, 1978,* p. 86). Slightly older children meet this criterion by default. Therefore, infants might prefer older children.

Finally, there are also reasons for infants to prefer adults. Csibra and Gergely (2006) put forward the idea of a natural pedagogy whereby infants are better disposed to quickly learn culturally relevant behaviour from adults. That is, on the one hand, adults naturally tend to mark their relevant behaviour by ostensive cues (e.g. motherese, lifting eyebrows, addressing the infant by name) when they interact with infants. On the other hand, infants are naturally prepared to correctly interpret ostensive and referential cues in order to learn the corresponding behaviour. By default, adults are more knowledgeable and experienced in many domains of everyday life than children or peers (VanderBorght & Jaswal, in press). Accordingly, infants might have a bias towards tracking an adult's action as compared to the actions of peers or older children. This idea can also be found in Bischof's (1985) "Zurich Model of Social Motivation" in which he claims that the relevance of another person increases with their age.

Supporting evidence for each of these hypotheses can be found in the infancy literature and will be summarized below. Each paragraph consists of two parts. In the first part of each paragraph I will review studies in which perceptual variables such as looking time in response to differently aged models were investigated. In the second part of each paragraph I will summarize studies investigating the impact of differently aged models on imitation. Because of the limited number of such infancy imitation studies, I also include those studies in which children participated as well.

Support for the hypothesis that infants prefer peers comes from studies of infant perception using differently aged models. McCall and Kennedy (1980) reported that 4-month-olds' looking time when directed at facial drawings of differently aged individuals increased with the decreasing age of the person. Moreover, Lewis and Brooks (1975) found that 16- to 18-month-old infants smiled and vocalized more often when they were presented with photographs of infants of their own age than with photographs of older individuals. Along these lines, Sanefuji, Ohgami, and Hashiya (2005) reported that 8-month-olds showed a preference for peers and adults but not for 3-year-olds. In their study, infants banged their arms more frequently during observation of adults and infants. However, there is some dispute as to whether this motor activity signifies a preference (Sanefuji et al. 2005, Sanefuji, Ohgami, & Hashiya, 2006b), frustration (Behne et al., 2005), or else a self-induced vestibular stimulation (Thelen, 1980). To my knowledge, peer imitation in infancy has only been tested in three studies. Hanna and Meltzoff (1993) reported that 14-month-olds are able to imitate their peers; however they did not compare peer imitation and adult imitation. In contrast, Abravanel and DeYong (1997) tested infants aged 3 and 6 months, but they found no consistent imitation of facial gestures either with a televised adult model, or with a cartoon animation of a 5 month old child. However, the notion that peers are imitated more often than adults was supported by imitation studies of preschoolers as well as school children. It was shown that children are per se capable of imitating their peers, but this ability was not systematically compared with the imitation of younger or older models (Abramovitch & Grusec, 1978; Lubin & Field, 1981; Morrison & Kuhn, 1983). Becker and Glidden (1979) found that when educable, mentally retarded children observed others playing a game a model's age influenced their likelihood of adopting the social behaviour. That is, the social behaviour of peer models was performed more often than the social behaviour of adult models. Additionally, Kornhaber and Schroeder (1975) assessed the effect of peer and adult models on children's method of coping with snakes. They found that modelling by peers was significantly more effective in reducing avoidance behaviour than modelling by adults. In studies by Brody and Stoneman (1981; 1985) children observed food preferences of differently aged children. Participants adopted the food preference of peers and older children more often than younger children.

In several studies, infants also displayed increased interest in older children. Infants responded positively to the body height and facial configuration typically associated with older children (Bigelow, MecLean, Wood, & Smith, 1990), they preferred children's faces over adults' faces (Bahrick, Netto, & Hernandez-Reif, 1998) and preferred the presence of older children compared to the presence of adults (Greenberg, Hillman, & Grice, 1973). Furthermore, in family day-care centres, toddlers spent more time looking at older children than at peers (Rothstein-Fisch & Howes, 1988). In the domain of imitation, Ryalls, Gul, and Ryalls (2000) reported a slightly increased imitative performance in 14- and 18-month-olds after having observed a 3-year-old model, as compared to their performance after having observed an adult model.

However, there is almost no evidence for a preference for adults in looking time studies except for Sanefuji et al. (2005) who reported increased motor activity when infants were presented with peers and adults as compared to their motor activity when they were presented with older children. However, this lack of evidence might be related to their emotional responses to adults: when infants encounter strangers at the end of the first year of life, they sometimes show stranger anxiety (Ainsworth & Wittig, 1969; Emde, Gaensbauer, & Harmon, 1976; Greenberg et al., 1973). This tendency to avoid adult strangers could possibly affect their reactions to the stimuli of adults in the laboratory. But, in most cases, infants express stranger anxiety when an adult approaches them rather than when he or she is simply present (Campos, Emde, Gaensbauer, & Henderson, 1975; Sroufe, 1977; Waters, Matas, & Sroufe, 1975). Consequently, if infants are only presented with televised adults or mere drawings of adults, the tendency to show stranger anxiety should be reduced (Bigelow et al., 1980; Sanefuji et al., 2005). In contrast, studies on infant imitation using differently aged models reveal evidence that imitation of adults is more widespread than imitation of younger models. Rakoczy, Hamann, Warneken, and Tomasello (2008), for example, reported that children were more likely to internalize the rules of a game that was set up by an adult rather than by a peer. Additionally, Mak (2005) reported that children are more likely to imitate a novel action witnessed in adults than in their peers. On the contrary, some studies have stressed the context in which children adopt behaviour from peers and adults. VanderBorght and Jaswal (in press) showed that when preschoolers were allowed to choose between a child informant and an adult informant in order to gain information about toys and food, children opted for the informant with the most expertise in the area (e.g., children chose to direct the food questions to the adult and the toy questions to the child). Along similar lines, Grusec and Abramovitch (1982) reported that in a naturalistic environment, children predominantly imitate games from peers and they imitate conformity-inducing behaviour (e.g., establishing rules) from adults.

To summarise, the existing literature provides ample evidence that infants and children are quite selective in their perception and their adoption of the modelled behaviour of differently aged models. However, the findings are anything but conclusive. The question arising from these studies is: how do we integrate the divergent findings of the infant and child literature? The answer may potentially lie in a framework suggested by VanderBorght and Jaswal's (in press) and Grusec and Abramovitch's (1982): the notion that context might influence the likelihood of a behavior being adopted from a particular age group.

1.2.3.3 A Model's Reliability

Imitation can be conceived of as a quick route to developing new strategies to problems one might encounter in the environment. But how adaptive is this route if you copy from conspecifics that have tackled the problem using inadequate methods? Would it not be wiser to copy the behaviour of a reliable model as compared to an unreliable model? This question has fuelled those studies looking at the social learning of communication skills (Sonnenschein & Whitehurst, 1980), a novel motor-skill task and a social behaviour task (Becker & Glidden, 1979), and paired-associate letter-number lists (Simon et al., 1975). Recently, a number of studies have shown that children as young as 3 years of age prefer to learn novel words from speakers who have previously named familiar objects correctly rather than from speakers who have previously named the objects incorrectly (Birch, Vauthier, & Bloom, 2008; Jaswal & Malone, 2007; Koenig, Clement, & Harris, 2004; Pasquini, Corriveau, Koenig, & Harris, 2007). Furthermore, if children witnessed an informant's reliability in a verbal task they extended their selective trust when this informant nonverbally demonstrated the function of a novel object (Koenig & Harris, 2005a). Wimmer, Hogrefe, and Perner (1988) have speculated on children's a priori assumption that adults are omniscient whereas peers are not. Interestingly, Jaswal & Neely (2006) tested the role of a model's reliability and a model's age in a single experiment. In their study, children observed both an adult and a child model, but only one was reliable in word labelling. Children were subsequently found to have selectively learned from the reliable model irrespective of the model's age. However, if the child as well as the adult model were reliable, children preferred to learn from the adult model.

Koenig and Echols (2003) showed that 16-month-old infants develop a concept of other human speakers as accurate communicators. In their study, infants heard true or false labels for common objects uttered by a human speaker seated next to them. Infants looked significantly longer at the human agent when a false label was uttered than when an accurate label was given to the object. 18-month-olds were also able to actively use this ability: they accepted true affirmative sentences but rejected false affirmative sentences (e.g., 'That's a ball' in reference to a car) by saying 'no' (Pea, 1982). Recent work by Chow, Poulin-Dubois, and Lewis (2008) has shown that 14-month-old infants are more likely to follow a person's gaze if this person has been a reliable looker in the past (i.e., if the person has expressed excitement when looking in containers with toys inside) than if this person has been an unreliable looker (i.e., if the person has expressed excitement when looking in empty containers). However, there have been no studies that have tested whether a 1-year-old's social learning is affected by the model's reliability.

To recapitulate, it is known that preschoolers preferentially learn from reliable models. Moreover, it is known that infants are able to detect a model's reliability. What is unknown is whether infants are able to actively use this capacity in order to selectively learn from reliable models.

1.2.4 Imitation from Televised and Live Models

When investigating infant competences in situations involving a second person, one can opt for presenting the other person live or one can decide to present the other person via television. In this dissertation we used televised models for the presentation of the target behaviour because this method allows greater control over variability within and between conditions especially when infants and children serve as models. Moreover, during shooting of the video sequences for the stimuli, we found repeatedly that it was a hopeless endeavour to make infants and young children demonstrate the same actions consistently.

In general, in a number of studies in various domains it has been shown that young children perform worse when these tests are presented via video compared to their performance when presented with a live model (see Povinelli, Landau, & Perilloux, 1996; Suddendorf, 1999 for self recognition; see Troseth & DeLoache, 1998 for a retrieval test). In fact, there is an indication that the so-called "video deficit" (Anderson & Pempek, 2005) occurs in imitation studies, too. That is, overall imitation rate is sometimes reduced (Barr & Hayne, 1999; Hayne, Herbert, & Simcock, 2003; Klein et al., 2006). Three reasons for the video deficit have been put forward. First, it has been suggested that infants form a 2D memory representation of the original 2D video display, but are then required to reproduce those perceptual attributes in a 3D test object (Barr, Muentener, & Garcia, 2007; Barr, Muentener, Garcia, Fujimoto, & Chavez, 2007; Suddendorf, Simcock, & Nielsen, 2007). This mapping might therefore be more demanding than when memory representation derives from a 3D live demonstration. Second, young children may fail to understand the representational nature of symbols such as television produces (Troseth & DeLoache, 1998). Third, infants might imitate less from television than from live modelling because they lack the motivation to do so. Along these lines, Nielsen, Simcock, and Jenkins (2008) provided evidence for the social dimension of imitation. Before conducting an imitation task, 2-year-olds were presented with the televised demonstrator. In one condition they could interact with him socially, in the other condition the model was videotaped and therefore could not provide any contingent feedback. Toddlers were found to imitate more actions in the condition with social feedback than in the condition with no social feedback (for an analogous effect in a hiding game where the toddler received the information from a televised model, see Troseth, Saylor, and Archer, 2006). However, Mumme and Fernald (2003) reported that 12-month-olds are not severely affected by learning from a televised model and a recent study by Barr et al. (2007) indicated that an increased exposure to the target action might reduce the video deficit in 12-month-olds. It is yet unknown why infants around 12 months are good at learning from televised models, whereas older infants and toddlers seem to show a deficit in learning from televised models. For the purpose of my dissertation, I concluded that the use of televised models is a good alternative to the use of live models if I was going to investigate infants under 12 months of age.

1.3 Outline of the Dissertation

The preceding review of the literature has provided evidence that infant imitation is influenced by a model's characteristics. However, several open questions remain after having reviewed these studies. One of the main questions of this dissertation was to investigate the role a model's age has with respect to such aspects as the novelty of the behaviour and the completeness of an action. It is important to investigate the role of a model's age in infancy for two reasons. First, in a natural setting, infants are usually taught by adult individuals, and for pedagogical reasons it is of great importance to know from which model infants can learn best. Second, when investigating imitation in an experimental setting infants are usually tested by adult experimenters, and as researchers infer the general cognitive abilities from these experiments, it is worth investigating whether infants are better or worse at imitating adult demonstrators. Furthermore, we assumed that a model's age influences the perceived reliability of a model. Therefore, we additionally tested the role of a model's reliability on infant imitation. In order to investigate these research questions we opted for the use of televised models; an experimental setup that had first to be validated.

In Experiment 1, therefore, we explored whether infants are able to detect the rationality of an adult's action when it is presented on TV. For this purpose we replicated and extended a study using a selective imitation task (Gergely et al., 2002). We investigated if 9- and 12-month-olds' imitation was influenced by a model's situational constraint when performing a novel action, and if this was the case, we were further interested in whether the nature of this constraint mattered (implicit and voluntary vs. explicit and non-voluntary).

In Experiment 2, we investigated the role of the model's age on 14-month-olds' imitation of novel and familiar behaviour. In Experiment 2a, infants observed novel action (as in Experiment 1). In Experiment 2b, we presented infants with familiar body movements performed by differently aged models. In both experiments, the corresponding behaviour was performed by differently aged models (same-aged peers, 3.5-year-old children, and adults).

In the first part of Experiment 3, we extended the findings of Experiment 2b. Fourteen-month-old infants observed differently aged models performing familiar object-directed actions. Thus, we could compare these findings directly to the findings of Experiment 2a where object directed (but novel) actions were demonstrated. In the second part of Experiment 3, we wanted to investigate whether a model's age influenced the re-enactment of failed attempts. Therefore, 14-month-olds observed how differently aged models tried but failed to perform a familiar object-directed action.

Finally, in Experiment 4, we investigated whether 14-month-old infants were more likely to imitate a novel action (as in Experiment 1 and 2) when this action was presented by a reliable model as compared to an unreliable model. In order to put the effect of a model's reliability into a broader context, we additionally tested the acquisition of individual preferences demonstrated by both the reliable and the unreliable model.

2 Experiment 1: The Development of Rational Imitation of Televised Models in 9- and 12-Month-old Infants

As noted above, a closer look at infants' imitative abilities in the last few decades has revealed that they are more sophisticated imitators than has been previously credited. Meltzoff (1988b, 2002 #124) showed in his seminal study that 14-month-olds are able to imitate novel goal-directed actions. Infants were confronted with a wooden box containing a hidden lamp, with its top surface covered in a translucent plastic panel. The box could be illuminated by touching the panel. When they had watched an adult performing the head touch to illuminate the box one week before, two thirds of infants engaged in this action. In contrast, infants never turned on the lamp by using their head spontaneously in a baseline control group. This task of illuminating a lamp with the head will be referred to as the *head touch task*.

Gergely et al. (2002) extended the head touch task by adding a second experimental condition. Infants performed the head touch less often when the model's hands were occupied by holding a blanket (hands-occupied condition) than when the model's hands were free (hands-free condition). The authors interpreted these findings as evidence that infants evaluated the behaviour of the model according to the situational constraints. In the hands-occupied condition, infants might have assumed that the model had to use the head, because the hands were occupied. Consequently, infants used their hands to turn on the lamp, because their hands were free. In contrast, in the hands-free condition, infants could have inferred that the model deliberately chose to use the head, as she could have used the hands instead. Gergely et al. (2002) hypothesized that by copying this unusual action infants investigated a possible benefit from this method of turning on the lamp.

In a recent study by Schwier et al. (2006) a different kind of task was designed in order to test infants' ability to imitate rationally. They reported that infants as young as 12-months already take into account situational constraints in their imitative behaviour. In the study of Schwier and colleagues (2006), the experimenter put a stuffed toy dog into a house through the chimney. In the door-closed condition (analogous to the hands-occupied condition in the head touch task) the experimenter was forced to use this method because the door was closed. In the door-open condition (analogous to the hands-free condition) the door was open, but the experimenter dropped the toy dog through the chimney just as in the door-closed condition. Twelve-month-olds imitated dropping the toy dog through the chimney more often in the door-open condition than in the door-closed condition. In line with Gergely et al. (2002), the authors concluded that young infants do imitate rationally. Furthermore, they provided evidence that even 12-month-olds show this ability.

It is important to note that there were at least two main differences in the studies by Schwier et al. (2006) and Gergely et al. (2002). First, the constraint on the agent's more straightforward action differed because the model in Gergely et al.'s (2002) study voluntarily occupied her hands by holding a blanket, but the dog in Schwier et al.'s (2006) study faced a non-voluntary external restriction (closed door) that made him change his intended pathway. Second, Schwier et al. (2006) and Gergely et al. (2002) tested different age groups (12- and 14-month-olds, respectively).

Thus, in order to investigate the developmental onset of rational imitation, we tested 9- and 12-month-olds' capacity for rational imitation using a condition in which the model's actions were involuntarily and explicitly restricted, and a condition in which the restriction was voluntary and implicit. For this purpose, we used Gergely et al.'s (2002) head touch task. In addition, we designed a new *hands-restrained* condition. In this new condition the hands of the model were tied to the table. This represents a non-voluntary and explicit restriction similar to the door-closed condition tested by Schwier et al. (2006).

Following this rationale, we expected that 12-month-olds would use their heads in order to turn on the lamp less often in the condition in which the model's hands were tied to the table (hands-restrained condition), compared to the condition in which the model's hands were free (hands-free condition). For the comparison between the hands-free and the hands-occupied condition (when the hands were occupied by holding a blanket) the prediction was less clear as there is no evidence yet that 12-month-olds detect implicit and voluntary constraints.

2.1 Method

2.1.1 Participants

Participants were 55 nine-month-olds (*M* = 9 months; 3 days, range 8;15 to 9;16, 27 girls and 28 boys) and 64 twelve-month-olds (*M* = 12 months, range 11;15 to 12;15, 30 girls and 34 boys). An additional 29 twelve-month-olds and 15 nine-month-old infants were tested, but not included into the final sample due to fussiness, interference by the parent, procedural errors, or lack of interest. Infants were recruited from a database of parents who have agreed to participate in infant studies.

2.1.2 Test Environment, Material and Stimuli

The lamp (diameter 14cm; height 5cm) was fixed on a wooden panel (19 x 27 cm) and could be automatically illuminated by touching it on the top. Video sequences were presented via the software presentation® on a 24 inch monitor (SONY GDM-FW900, screen solution 800 x 600). A table (80cm x 60cm) was located between the monitor and the infant. The distance between the infant and the monitor was about 70 cm. In the three experimental conditions the model illuminate the lamp by using the head and in one baseline condition the model illuminated the lamp by using the hand.

<u>Hands-free condition:</u> The hands of the televised model were located beside the lamp. A blanket was wrapped around the shoulders, but did not constrict the model. The model clapped on the table three times by lifting both hands simultaneously a few centimetres. After that, the model illuminated the lamp for two seconds using the forehead (see Figure 1a) and then returned to the initial position.

<u>Hands-occupied condition:</u> The model's hands were located beside the lamp. The model took the ends of the blanket, wrapped them around the shoulders so that the hands were covered by the blanket and illuminated the lamp by using the head (see Figure 1b). Afterwards the model returned to the initial position.

<u>Hands-restrained condition:</u> The model's hands were located beside the lamp. The hands were tied to the table with two black tapes (width 5 cm). A blanket was wrapped around the shoulders, but did not constrict the model. The model clapped on the table three times as in the hands-free condition thereby illustrating that lifting the hands is not

possible. Subsequently, the model illuminated the lamp using the head (see Figure 1c). Afterwards the model returned to the initial position.

<u>Baseline condition:</u> The model's hands were located beside the lamp. A blanket was wrapped around the shoulders, but did not constrict the model. The model used the right hand to turn on the light (see Figure 1d). Then the model returned that hand to the initial position.

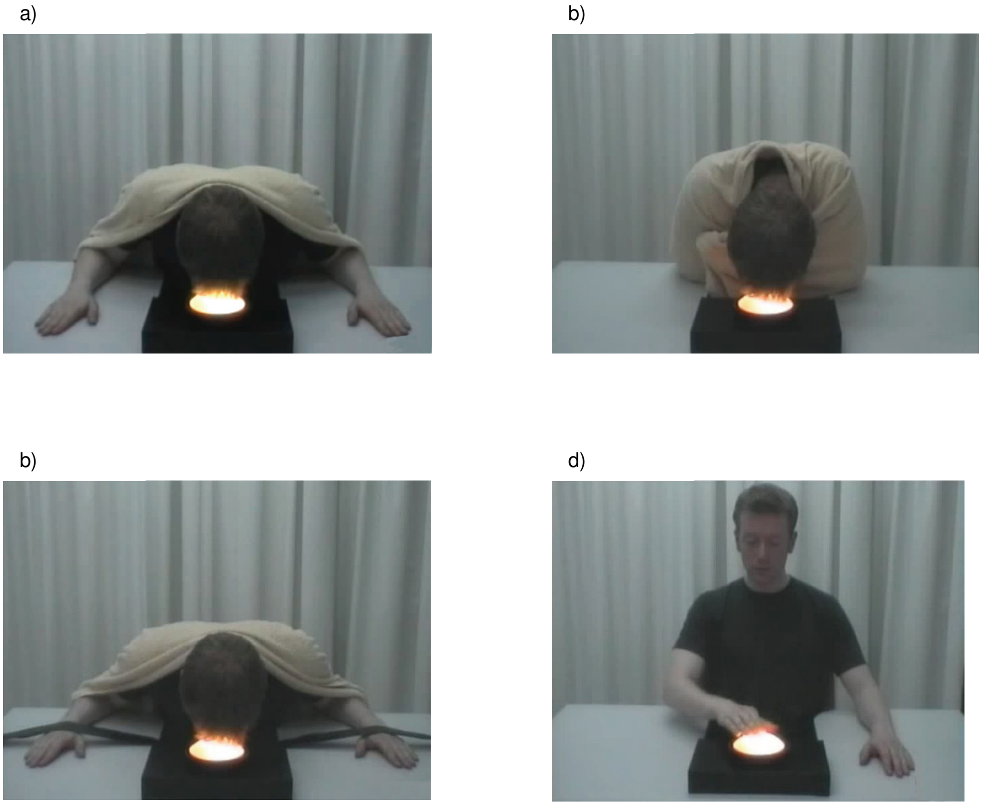

Figure 1. Illuminating the lamp in the a) hands-free, b) hands-occupied, c) hands-restrained, and d) baseline condition.

The model was either a female or a male adult. Note that in each of the three head touch conditions the model performed an action before performing the head touch. That is, clapping on the table was presented in the hands-free and hands-restrained conditions, and wrapping the blanket around the shoulders was presented in the hands-occupied condition. Therefore, experimental conditions were comparable in this respect.

Each video sequence lasted for 10 seconds. We used a picture of a sun together with a male voice saying “Look, there!” as an audio-visual attention-getter that was presented for three seconds before each presentation of a video sequence. The model did not talk to or look at the infant in all four conditions. Instead the model looked solely at the lamp with a neutral facial expression. Accordingly, and unlike in Gergely et al.’s (2002) original study, the model in the hands-occupied condition did not pretend to be cold in order to keep emotional cues constant across conditions and to focus on the occupied and restrained status of the hands, respectively. Although it is more common in imitation research to present target actions three times, we presented the video sequence five times as a pilot study, and a recent study by Barr et al. (2007) indicated that an increased exposure to the target action might reduce the video deficit in 12-month-olds.

2.1.3 Procedure

Infants were randomly assigned to one of the four conditions. Infants sat on their parent's lap. Parents were instructed to hold their infant at the hip in order to ensure an upright position and mobility of the upper part of the body. When parent and child felt comfortable, the experimenter left the room and started a computer controlled presentation of the stimulus material. After the video demonstration, the experimenter came back to the testing room, placed the lamp in front of the infant, fixed it to the table using double faced adhesive tape and left the room again. Whereas the test phase used by Gergely et al. (2002) was 20 seconds, we used a prolonged test phase of 60 seconds because infants in the present study engaged in the head touch action less swiftly than reported by Meltzoff (1988b) and Gergely et al. (2002). During the presentation of the video sequences and during the test phase, a camera was positioned above the monitor and recorded a close-up view of the infant. Additionally, a second camera was focused on the monitor to document the demonstrated video sequences. Both camera views were recorded on one tape using a split screen generator.

2.1.4 Data Analysis

An action was coded as head touch if infants approached the lamp with their head and the minimal distance between their head and the lamp was below 10 cm. This coding procedure is analogous to previous studies using the head touch task (Gergely et al., 2002; Meltzoff, 1988b). In addition to the dichotomous classification of infants who performed the head touch and those who did not, we coded the number of head touches as well as the latency of the first occurrence of the head touch. The onset for the latency measurement was the point in time when infants saw the lamp and had free access to it. A second independent observer rated 25 % of the videos. Good levels of reliability (Intraclass correlation coefficient) were achieved for looking time (.90), number of hand (.96) and head touches (.96) and latency of the first occurrence of the head touch (.93). Because coding happened to be on a nominal scale, two-tailed χ^2-tests were applied. For analyzing looking time, number of hand and head touches and latency of the first occurrence of the head touch, ANOVAs were used.

2.2 Results

Infants were highly interested in the video sequences and in the lamp. Total presentation time of the video sequences was 50 seconds. Looking time in each condition ranged between 35 seconds and 46 seconds (see Table 1) and did not differ significantly between conditions in each age group (both p's > .20). Moreover, all infants turned on the lamp by using the hand at least once during the test phase.

Eight out of fourteen 9-month-olds (57%) performed the head touch in the hands-free condition, 7 out of thirteen 9-month-olds (54%) in the hands-occupied condition, 8 out of fourteen 9-month-olds (57%) in the hands-restrained condition and 9 out of fourteen 9-month-olds (64%) in the baseline condition (see Figure 2). There was no significant difference in performing the head touch across all four conditions in 9-month-olds (all p's > .55).

Twelve out of sixteen 12-month-olds (75%) performed the head touch in the hands-free condition. Eight out of sixteen 12-month-olds (50%) performed the head touch in the hands-occupied condition. In contrast to the results reported by Gergely et al. (2002) with 14-month-olds, this difference in producing the target action failed to reach significance, $\chi^2(1, N = 32) = 2.13$; $p = .14$. Only 4 out of sixteen 12-month-olds (25%) performed the head touch in the new hands-restrained condition, in which the hands were tied to the table. The difference between the hands-free and hands-restrained condition was statistically significant, $\chi^2(1, N = 32) = 8.00$; $p < .01$. A separate analysis using a stricter criterion for coding the head touch (only a head touch with physical contact with the lamp was coded) revealed that seven 12-month-old infants who were previously coded as performing the head touch had to be coded as using the hands only. However, these infants were equally distributed across the three experimental conditions (3 in the hands-free conditions, 2 in the hands-occupied condition, and 2 in the hands-restrained condition) with no infant in the baseline condition. In the group of the nine-month-olds, all infants who were previously coded as performing the head touch touched the lamp by using the head at least once. Consequently, the pattern of results did not alter when a stricter criterion for coding the head touch was applied.

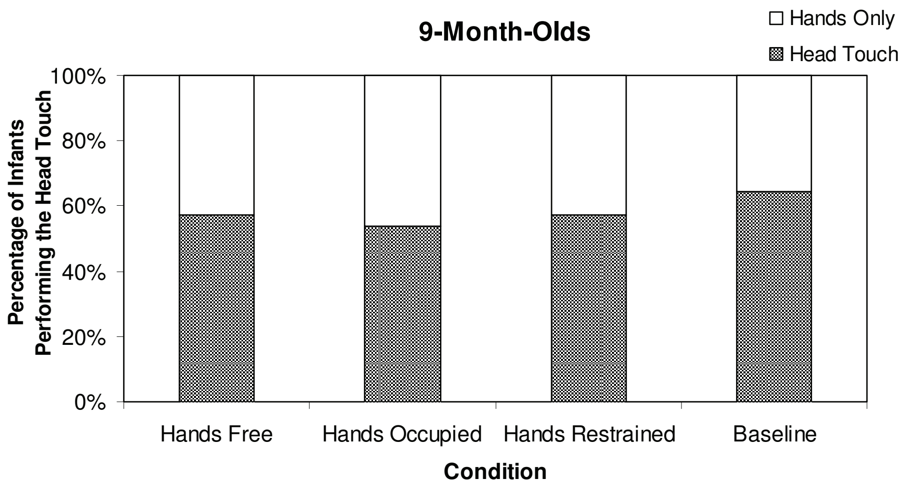

Figure 2. Percentage of 9-month-olds performing the head touch at least once in each condition.

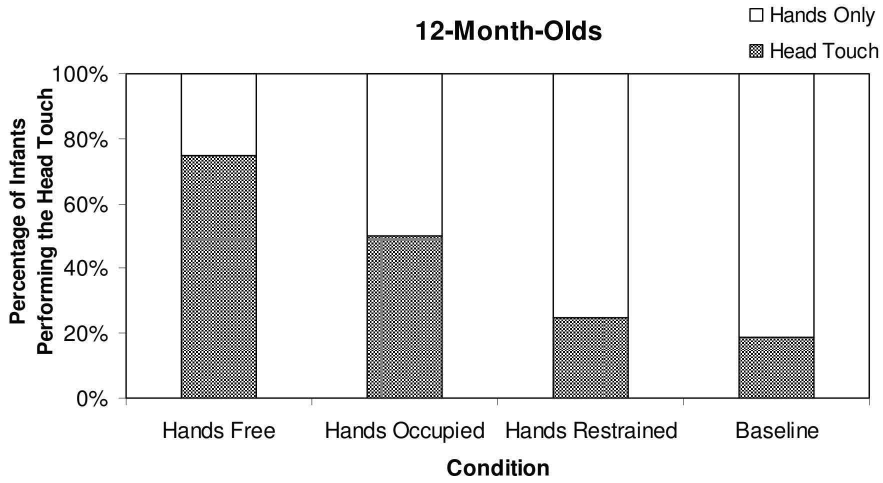

Figure 3. Percentage of 12-month-olds performing the head touch at least once in each condition.

No significant difference was found when comparing the hands-occupied condition with the hands-restrained condition, $\chi^2(1, N = 32) = 2.13$; $p = .14$. Only 3 out of sixteen 12-month-olds (19%) performed the head touch in the baseline condition (see Figure 3). The performance in the baseline condition differed significantly from the hands-free condition, $\chi^2(1, N = 32) = 10.17$; $p < .001$. There was a marginal significant difference between the hands-occupied and the baseline condition, $\chi^2(1, N = 32) = 3.46$; $p = .06$, but not between the hands-restrained condition and the baseline condition*;* $\chi^2(1, N = 32) = .00$; $p = 1.00$; Fisher's Exact Test. Additionally, there were no differences in the imitative behaviour between infants perceiving the male model and infants perceiving the female model.

In both age groups (9- and 12-month-olds) the mean number of head touches did not differ across the four conditions, $F(3, 28) = 1.32$; $p = .29$; $F(3, 23) = 2.07$; $p = .13$, respectively, nor did the latency of the first occurrence of the head touch, $F(3, 28) = 1.95$; $p = .14$; $F(3, 23) = 1.14$; $p = .35$, respectively. Similarly, the mean number of *hand* touches in the group of 9-month-olds (hands-free: 19.1; hands-occupied: 16.0; hands-restrained: 20.6; baseline: 12.9) and in the group of 12-month-olds (hands-free: 16.6; hands-occupied: 21.9; hands-restrained: 16.5; baseline: 20.6) did not differ significantly, $F(3, 51) = 1.83$; $p = .15$; $F(3, 60) = 1.05$; $p = .38$, respectively. Table 1 shows the mean number of hand touches, the mean number of head touches and latency of the first occurrence of the head touch.

Table 1. *Looking Time, Latency of Occurrence of the First Head Touch and Mean Number of Head Touches in Each Condition for Each Age Group. Standard Deviations are Given in Parentheses.*

	Mean looking time (sec)	*Mean latency of occurrence of the first head touch (sec)*[a]	*Mean number of head touches*[a]
9-month-olds			
Hands free	42.5 (7.3)	35.7 (15.3)	2.1 (1.1)
Hands occupied	35.5 (9.5)	24.9 (7.5)	3.0 (2.3)
Hands restrained	40.4 (7.2)	24.4 (18.8)	3.1 (3.1)
Baseline	39.8 (4.2)	15.0 (22.9)	4.4 (2.7)
12-month-olds			
Hands free	42.0 (7.3)	26.6 (17.1)	5.3 (4.3)
Hands occupied	43.1 (7.9)	34.3 (16.9)	2.0 (2.1)
Hands restrained	41.2 (6.6)	19.7 (18.7)	3.5 (2.6)
Baseline	45.0 (5.7)	39.1 (6.3)	1.3 (0.6)

[a]Only infants who performed the head touch were included in this calculation.

2.3 Discussion

Experiment 1 aimed at answering two theoretical questions and one methodological question. First, are infants able to imitate rationally at 12 months of age? The answer to this question is yes. The present study shows that the developmental onset of the ability to imitate rationally is between 9 and 12 months of age. Second, what are the conditions, under which infants start to imitate rationally? The results of the present study indicate that infants are more sensitive to an explicit and non-voluntary contextual constraint than to an implicit and voluntary contextual constraint. 12-month-olds, but not 9-month-olds, imitated the head touch rationally when comparing the performance of the head touch in the hands-free to the hands-restrained condition, but showed no context effect when comparing the performance of the head touch in the hands-free to the hands-occupied condition. Third, are infants able to detect and use sophisticated information from televised models such as situational constraints? Yes, they are. Similar to previous studies showing that infants around 12 months of age are not heavily affected be televised information (Barr, Muentener, & Garcia, 2007; Mumme & Fernald, 2003), the results of this study are encouraging for further investigate infant imitation with televised demonstration.

In general, imitative abilities develop rapidly between the age of 9 and 12 months (Anisfeld, 2005; Carpenter, Nagell, & Tomasello, 1998; Jones, 2007). In line with this developmental trend, the present study reveals that 12-month-olds, but not 9-month-olds, engage in rational imitation in the head touch task. But note that McCall (1974) reported that the amount of "mouthing" in order to explore a toy decreases substantially from 8.5 to 11.5 months of age. It is possible that the dominant tendency in 9-month-olds to explore objects orally obscured the ability to imitate rationally in the head touch task. Although a detailed analysis of the head touch behaviour (latency of the first occurrence of the head touch and mean number of head touches) did not support this idea, one should interpret the negative result obtained in the 9-month-olds with caution.

Experiment 1 shows under which conditions 12-month-olds are able to imitate rationally: the context-sensitive contrast in imitation was only present when comparing the hands-free and hands-restrained condition. But in contrast to the 14-month-olds in the study of Gergely et al. (2002), 12-month-olds did not discriminate between the hands-free and hands-occupied condition. Thus, infants were more sensitive to the explicit and non-voluntary constraint, represented by the tied hands in the hands-restrained condition, than to the implicit and voluntary constraint in the hands-occupied condition (i.e., holding a blanket). Similar to the suggested developmental trend in rational imitation between infants of 12- and 14-months, a change in the imitative ability between infants of 12- and 15-months has also been reported in previous research on intended but unfulfilled acts (Bellagamba & Tomasello, 1999; Johnson et al., 2001).

Despite the similarity between the present study and the study by Gergely et al. (2002), the present study differed with respect to the method used to demonstrate the model's action (live vs. televised demonstration). In general, there is no reason to assume that differences between a televised and a live demonstration could account for the presence of rational imitation in the hands-free and hands-restrained condition and the absence of it in the hands-free and hands-occupied condition, because both comparisons are based on the same difference in stimuli type. However, there is the possibility that the less social nature of the video demonstration produced a qualitatively different task compared to the head touch task by Gergely et al. (2002). Klein et al. (2006) reported that the imitative behaviour of 12-month-olds who watched a televised demonstration of a three step action was analogous to the performance of infants who perceived a live demonstration, but that the overall imitation rate was reduced. A similar overall reduction in the rate of imitation was reported in other studies as well (Barr & Hayne, 1999; Meltzoff, 1988a). However, a decreased imitation rate was not prevalent in the current study, as the rate of imitation in the hands-free condition (75%) was comparable to previous studies using live models. In Schwier et al.'s (2006) study 81% of infants used the chimney pathway in the door-open condition, and in Gergely et al.'s (2002) study 69% of infants performed the head touch in the hands-free condition. Thus, one might assume that in this study the less social nature of the presentation did not have a fundamental impact on the performance of the head touch. This is in line with a differentiation suggested by Uzgiris (1981) between a social and a cognitive function of imitation. According to Uzgiris, the social function of imitation refers to an affective sharing between model and imitator and serves as a communicative act. The cognitive function of imitation helps the infant in understanding puzzling events and exploring novel aspects of reality. Uzgiris (1981) and others (Killen & Uzgiris, 1981; Nielsen, 2006) have suggested that in the course of the second year of life the cognitive function of imitation gradually pales in comparison to the social function of imitation. Presumably, infants perceive the head touch task in terms of a cognitive task rather than as an initiation of an interpersonal communication regardless of its live or televised demonstration. Accordingly, the reduced social nature of videotaped information might not affect young infants as much as previously claimed (Nielsen et al., 2008; Troseth et al., 2006).

Paulus, Hunnius, Vissers, and Bekkering (2008) assumed that infants in the hands-restrained condition might have perceived a failed attempt to illuminate the lamp by using the hands when the model clapped on the table three times illustrating that lifting the hands was not possible. Infants therefore re-enacted the hand touch afterwards. Indeed, there are studies showing that infants in their first year of life are able to re-enact failed attempts (Hamlin et al., 2008; Legerstee & Markova, 2008). However, in these studies a model's failed attempt was clearly related to an object whereas in Experiment 1, clapping on the table was not directed towards the lamp. Therefore, we believe that it is unlikely that infants perceived the model's in the hands-restrained condition as a failed attempt to illuminate the lamp by using the hand. However, even if one assumes that infants inferred that the model attempted to illuminate the lamp with the hand, Paulus et al.'s (2008) explanation is not consistent with other studies on infants' imitation. Nielsen (2006) showed that 12-month-olds did not foremostly re-enact failed attempts but they selectively copied actions of the model if given a logical reason to do so. That is, infants perceived how a demonstrator failed to open a box with the hand. The model then successfully opened the box with a tool. Infants copied the tool use in this condition more often than in a condition where the model only opened the box by using the tool without a prior attempt to open it with the hand. In Nielsen's (2006) study, the situational constraints were identical in both conditions for the model and the infant. Therefore, infants in the condition where the model failed to open the box with the hand probably assumed that they themselves would fail to open the box with the hand, too. Accordingly, infants copied the tool use. In contrast, in Experiment 1, the situational constraints of the model and of the infant differed in the hands-restrained condition. Therefore, infants probably assumed that they themselves would successfully illuminate the lamp with the hands. Accordingly, infants used their hands and not the head. Thus, Paulus et al.'s (2008) interpretation does not explain the results of Nielsen's (2006) study. The leanest explanation for Nielsen's (2006) study and Experiment 1 is that 12-month-olds predominantly imitate others if they assume that there is a good reason for others' behaviour.

In Experiment 1 we showed that the nature of a constraint matters when infants evaluate other people's novel actions. We argued that when emphasizing that the model is unable to use the hands, infants already have the capacity to detect the constraint on the model by the age of 12 months. It has been shown that infants around this age differentiate whether an adult is unwilling or unable to perform an action (Behne et al., 2005). When learning novel behaviour, the importance of infants being sensitive to the reason why a person performed an action cannot be overstated. Although they might not understand the particular reason for an action, they are able to more flexibly adapt their effort to acquire new skills. This ability has been suggested as an important step for entering cultural activity where the conventional use of artefacts is essential (Tomasello, 1999).

To summarise, the present study provides further evidence that 12-month-olds take into account the model's situational constraints when imitating others, whereas 9-month-olds do not yet engage in rational imitation. More specifically, 12-month-olds are sensitive to the model’s explicit and non-voluntary constraint but not if the constraint is an implicit and voluntary one. Furthermore, infants are capable of detecting sophisticated information from televised models and they use this information for adjusting their imitative behaviour.

3 Experiment 2: Infants' Imitation of Novel and Familiar Behaviour Performed by Differently Aged Models

In her seminal work, Uzgiris (1981) differentiated between a cognitive and a social functions of imitation. On the one hand, infants use imitation to acquire new skills and to understand puzzling events in the world (cognitive function), on the other hand, infants use imitation to create a social bond with another person via shared experience (social function). With regard to this differentiation, we assumed that infants' imitative behaviour might be modulated by the age of the model. More precisely, we suspected that a peer model's behaviour would be most similar to the infant's, whereas an adult model's behaviour would be the most competent. Thus, an adult model might more often cause imitation as a cognitive function whereas a peer model might more often cause imitation as a social function. Therefore, the social and cognitive function of imitation is described in detail and related to studies on infant attention and imitation.

The cognitive function of imitation relies on the assumption that children use imitation in order to acquire novel skills and to understand puzzling events in the world. Therefore, it would be wise for infants to socially learn from knowledgeable others. Vygotzky (1978) emphasized the importance of experienced conspecifics as well as Bandura (1977) who identified the social power and social status of a model as facilitating factors for imitation. According to Vygotzky (1978), knowledgeable others provide information that the child itself has little or no knowledge about. By adapting their instruction to the child's present abilities a zone of proximal development is created that guides the child's cognitive progress. Examples of children's sensitivity to the model's characteristics are provided by results from recent studies showing that preschoolers trust reliable rather than unreliable models when learning novel words (Birch & Bloom, 2002, Koenig & Harris, 2005b). Along this line, Gergely et al. (2002) showed that infants imitate a model that used her head to illuminate a box only if the model's hands were free. However, infants did not imitate this novel action when the model's hands were occupied. As the hands of the model in the first condition could have been used, infants might infer that the head provided some opaque advantage for illuminating the box. This finding has received further support from other studies on selective imitation (Buttelmann, Carpenter, Call, & Tomasello, 2008; Király, 2009; Schwier et al., 2006). One can conclude that infants imitate only those parts of actions that are perceived as containing new and relevant information, whereas they ignore arbitrary actions. Csibra and Gergely (2006) assumed selective learning can be explained by an innate mechanism, which adapts human infants to receive knowledge from adults who are by default perceived as omniscient and benevolent. In sum, based on the cognitive function of imitation one could assume that infants imitate adults because they are presumably perceived as more competent than children and infants.

As noted above, the social function of imitation is conceived as a non-verbal form of interacting with others. From very early in ontogeny, infants are sensitive to social contingency (Gergely & Watson, 1999) and to interpersonal timing (Striano, Henning, & Stahl, 2006) in mother-infant dyads. This ability is fundamental for social interaction where both interaction partners perceive each other as responsive. Nadel, Guérini, Pezé, and Rivet (1999) and Nadel-Brulfert and Baudonnière (1982) noted that imitating another person might be regarded as a non-verbal way of communicating. Nadel et al. (1999) reported that imitation for communicative purposes increases until it peaks at 3 years of age and then declines proportional with better command of the language. Preverbal infants do not yet possess symbolic means like a formal language to communicate and therefore need to rely on a more embodied form of communication as represented by imitation (Daum, Sommerville, & Prinz, in press). Along these lines, Nielsen and Slaughter (2007) pointed out that the social function of imitation has been neglected in many studies on infant imitation. For example, synchronic imitation in 18-month-olds has originally been interpreted cognitively. It was hypothesized that the ability to form secondary representations facilitated the coordination of a child's own behaviour with another's behaviour which then lead to the ability to imitate synchronically (Asendorpf & Baudonniere, 1993). But, during their second year of life, young children become increasingly motivated to interact socially with others via imitation (Nielsen, 2006; Uzgiris, 1981), therefore one might alternatively interpret synchronic imitation in 18-month-olds as fulfilling a social motive. Nielsen et al. (2008) provided further evidence for the social dimension of imitation. Before conducting an imitation task including a televised model, 2-year-olds could see the same demonstrator on the monitor. In one condition they could interact with him socially, in the other condition the model was videotaped and therefore could not provide any contingent feedback. Infants imitated more actions in the condition with social feedback than in condition without social feedback. Eckerman, Davis, and Didow (1989) showed that imitating the behaviour of peers is a predominant strategy for achieving social co-ordinations in one and two year-olds. Even adults sometimes use this strategy to non-consciously affiliate with another person non-verbally (Lakin & Chartrand, 2003; Lakin, Jefferis, Cheng, & Chartrand, 2003). Accordingly, peer imitation might serve as a social function; it provides a common ground on which shared experience can be established. Studies on infant attention have provided compelling evidence that infants are more interested in other infants or older children than in adults, when presented with pictures, (Bahrick et al., 1998; Bigelow et al., 1990; Lewis & Brooks-Gunn, 1975; McCall & Kennedy, 1980), videos (Sanefuji et al., 2005), or live models (Greenberg et al., 1973). It was assumed that infants are attracted by other infants and children due to the reduced stranger anxiety (Bigelow et al., 1990) and due to the emerging concept of self which might be more easily developed in the presence of similar others (Brooks & Lewis, 1976; Sanefuji et al. 2006b). In sum, one could suggest that infants imitate peers in order to interact with them socially.

The main goal of our study was to find out to what extent, and under what conditions, imitation depends on similarity vs. competence. We reasoned that if similarity counts, infants should always be more inclined to copy their peers as compared to older models. Conversely, if competence counts they should always prefer competent and reliable models for imitation over less competent and reliable models. Furthermore, we suspected that our findings might be modulated by action familiarity. We reasoned that the demonstration of novel actions might be seen to establish an opportunity to learn a novel skill from the model. Conversely, the demonstration of familiar body movements might be seen to create an opportunity to communicate non-verbally and share experiences. If this reasoning is valid one should see a stronger role for the adult in Experiment 2a as compared to Experiment 2b and a stronger role for the peer in Experiment 2b as compared to Experiment 2a. We included an intermediated age group (older child models) because Ryalls et al. (2000), who similarly investigated imitation of differently aged models, also used an older child model.

3.1 Experiment 2a: Imitation of Novel Behaviour

In Experiment 2a, we investigated the influence of the model's age on infants' imitation of a novel action. Therefore, we used the head touch task as introduced by Meltzoff (1988). In a between-subject design, 14-month-old infants were presented with a model of one of three different age groups (peer, older child, or adult) who illuminated a lamp by using the head. Head touches and looking time, were measured and analyzed.

3.1.1 Method

3.1.1.1 Participants

Participants were seventy-two 14-month-olds (M = 13;29, range 13;15 to 14;15; 34 girls, 38 boys). Fifteen additional infants were tested, but not included in the final sample due to fussiness, interference by the parent, procedural errors, or lack of interest.

3.1.1.2 Test Environment, Material and Stimuli

The technical equipment, the test material and the test environment of Experiment 1 were identical to the one in Experiment 2a. Fourteen-month-olds that were invited to model the head touch action always used the mouth and not the forehead to illuminate the lamp when they performed the head touch. Consequently, the older models were asked to perform the same action in order to keep the demonstration similar across models. However, this action will also be labelled as *head touch*.

In the three experimental conditions, the model was either a male 14-month-old infant (peer model condition, see Figure 4a), a 3.5-year-old boy (older child model condition, see Figure 4b), or a 22-year-old male adult (adult model condition, see Figure 4c). In an additional baseline condition, infants could explore the lamp without any previous video stimulus being presented. The demonstration of the head touch was identical across the models with respect to hand position (hands were put beside the lamp), accuracy of the head touch and duration of illumination of the lamp (2 seconds).

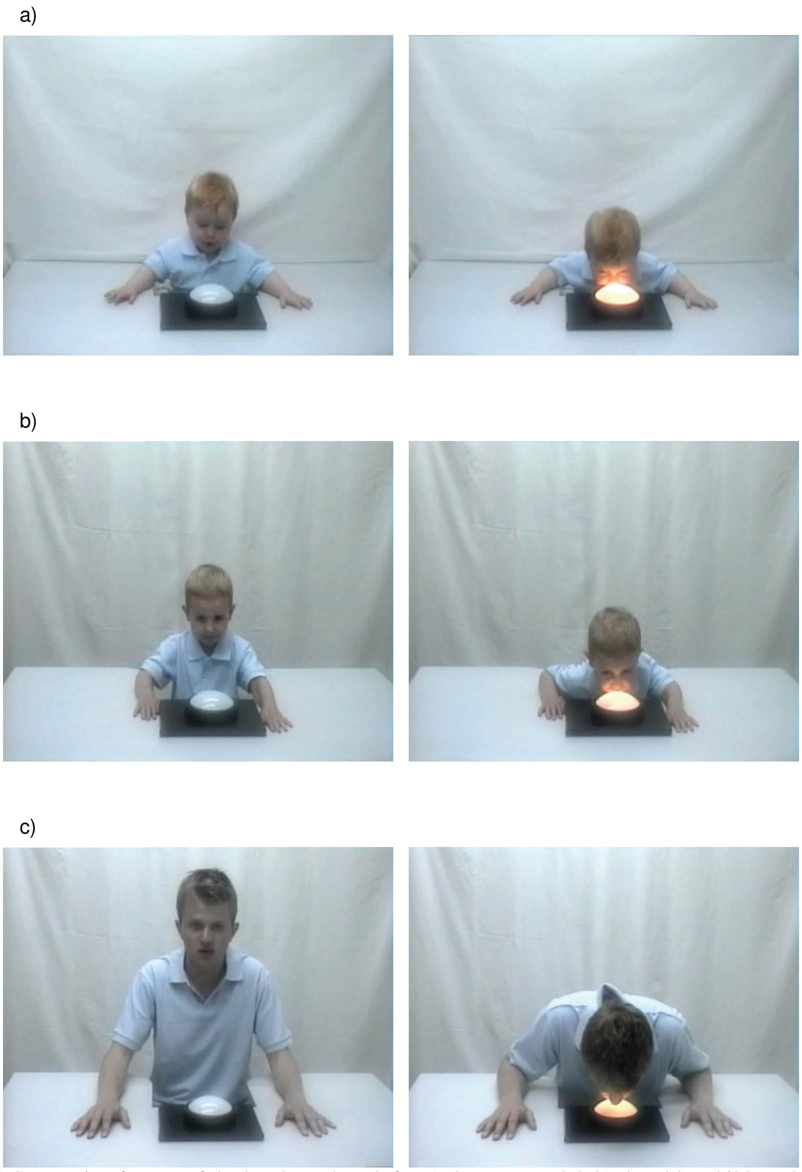

Figure 4. Successive frames of the head touch task for a) the peer model, b) the older child model, and c) the adult model.

Duration of each video sequence was 4.4 seconds. Prior to each video sequence, we presented the same audio-visual attention-getter as in Experiment 1. The model did not talk to the infant, the eyes of the model were not directed towards the camera, and the model had a neutral facial expression. The identical lamp was used during stimulus presentation and in the testing phase. During the whole experiment, infants sat on their parent's lap at a table (80cm x 60cm), which was located between the monitor and the infant. The distance between the infant and the monitor was approximately 70 cm. During the presentation of the video sequences and during the testing phase, a camera was positioned above the monitor and recorded a close-up view of the infant. Additionally, a second camera was focused on the monitor to record the demonstrated video sequences.

3.1.1.3 Procedure

Infants were randomly assigned to one of the four conditions. All infants were tested individually with one parent present. In the experimental conditions, the experimenter left the room and started the computer-controlled presentation of the stimulus material. Each video sequence (including the attention-getter and the model performing the head touch) was presented six times. Then the experimenter came back to the testing room, fixed the lamp on the table in front of the infant and left the room again. In this testing phase, the monitor in front of the infant displayed a black screen and the infant could play with the lamp for 60 seconds. In the baseline condition, infants could play with the lamp for 60 seconds without any prior video demonstration.

3.1.1.4 Data Analysis

Infants' behaviour and looking time were coded from video by a trained observer. An action was coded as head touch, if the infant attempted to touch the lamp by using the head in the first 60 seconds after the lamp was fixed on the table. Such an attempt was defined by a controlled head-movement towards the lamp so that the distance between head and lamp was less than 10 cm (see Gergely et al., 2002; Meltzoff, 1988, for a similar coding criterion). A second independent observer coded 100 % of the videos rating whether infants performed the head touch. The agreement with the first observer was .97 (Cohen's kappa). Because of the deviance of the error variance of the looking time data from the normal distribution, the data were analyzed non-parametrically. Coding of the head touch happened to be on a nominal scale, therefore, two-tailed χ^2-tests were applied. For the three experimental conditions, the looking times were compared by performing Kruskal-Wallis tests.

3.1.2 Results and Discussion

Infants were highly interested in the task. All infants turned on the lamp using their hands at least once. Figure 5 shows the percentage of infants copying the head touch action. The difference in the head touch performance between experimental conditions was significant, $\chi^2(2, N = 54) = 7.42$, $p < .05$, Chi square test. Numerically, infants were more likely to imitate the model the older the model was. This trend was supported by a significant correlation between the performance of the head touch and the model age group ($r = .37$, $p < .01$; Spearman's rank correlation). Only in the adult model condition did the head touch performance differ significantly from the baseline condition, $\chi^2(1, N = 36) = 9.26$, $p < .01$, Chi square test with Bonferroni correction for multiple comparisons. Infants in all conditions watched the demonstration closely (adult model: 88.8%, *S.E.* = 2.4% of the time; older child model: 79.0%, *S.E.* = 4.3%; peer model: 90.3%, *S.E.* = 2.7%, $\chi^2(2, N = 54) = 5.08$, $p = .08$, Kruskal-Wallis-test).

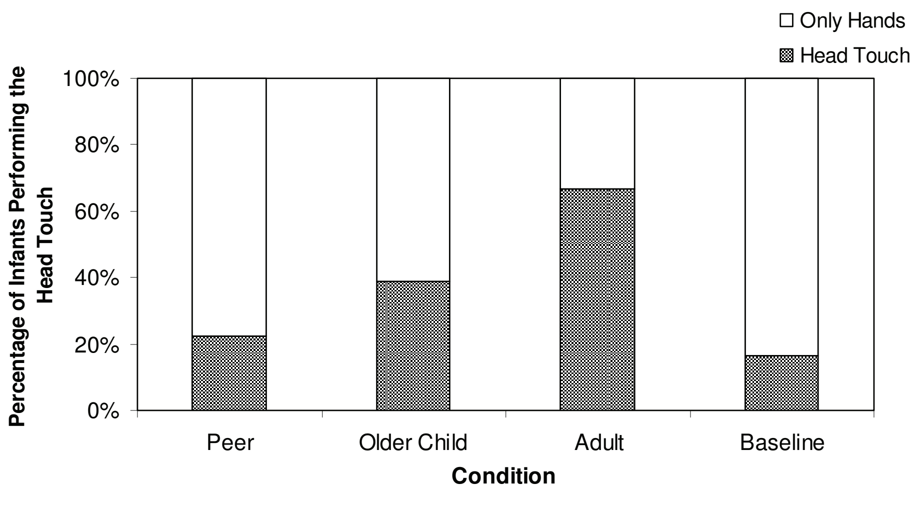

Figure 5. Percentage of infants performing the head touch at least once in each condition.

The results from the first study indicate that the likelihood of imitating a novel action increases as the age of the model increases. From the perspective of a cognitive and a social function of imitation one may conclude that infants apply predominantly the cognitive function of imitation when a novel action is presented. Infants rely on adults that are presumably perceived as more competent rather than on older children or peers that are presumably perceived as less competent.

3.2 Experiment 2b: Imitation of Familiar Behaviour

In Experiment 2b, we tested infants in a context that did not provide the opportunity to learn a novel skill but to perceive highly familiar body movements (e.g., clapping). We suspected that in this context infants would be less inclined to learn but rather to communicate non-verbally. Accordingly, we compared whether infants react differently in their imitative behaviour when watching familiar behaviour (Experiment 2b) and novel behaviour (Experiment 2a).

3.2.1 Method

3.2.1.1 Participants

Participants were thirty-six 14-month-olds (*M* = 13;28, range 13;15 to 14;15 days, 20 girls, 16 boys). Five additional 14-month-olds were tested, but not included in the final sample due to fussiness, interference by the parent or lack of interest.

3.2.1.2 Test Environment and Stimuli

The test environment was identical to Experiment 2a. Each video sequence presented a male model of one of three age groups performing the following four body movements: '*Banging'* (the model raises his hands up to the head and bangs on a table making a corresponding noise), '*Waving'* (the model repeatedly moves his hand up and down), '*Clapping'* (the model claps his hands in front of his body making a clapping noise, see Figure 6), '*Hand-to-mouth'* (this action consists of a controlled arm movement towards the mouth, so that the fingertips touch the mouth).

A pseudo-randomization of the body movements ensured that those body movements with noise (clapping and banging) and those that were silent (waving and hand-to-mouth) were presented in an alternating and counterbalanced order. Infants were randomly assigned to one of the three experimental conditions (peer, older child, or adult model).

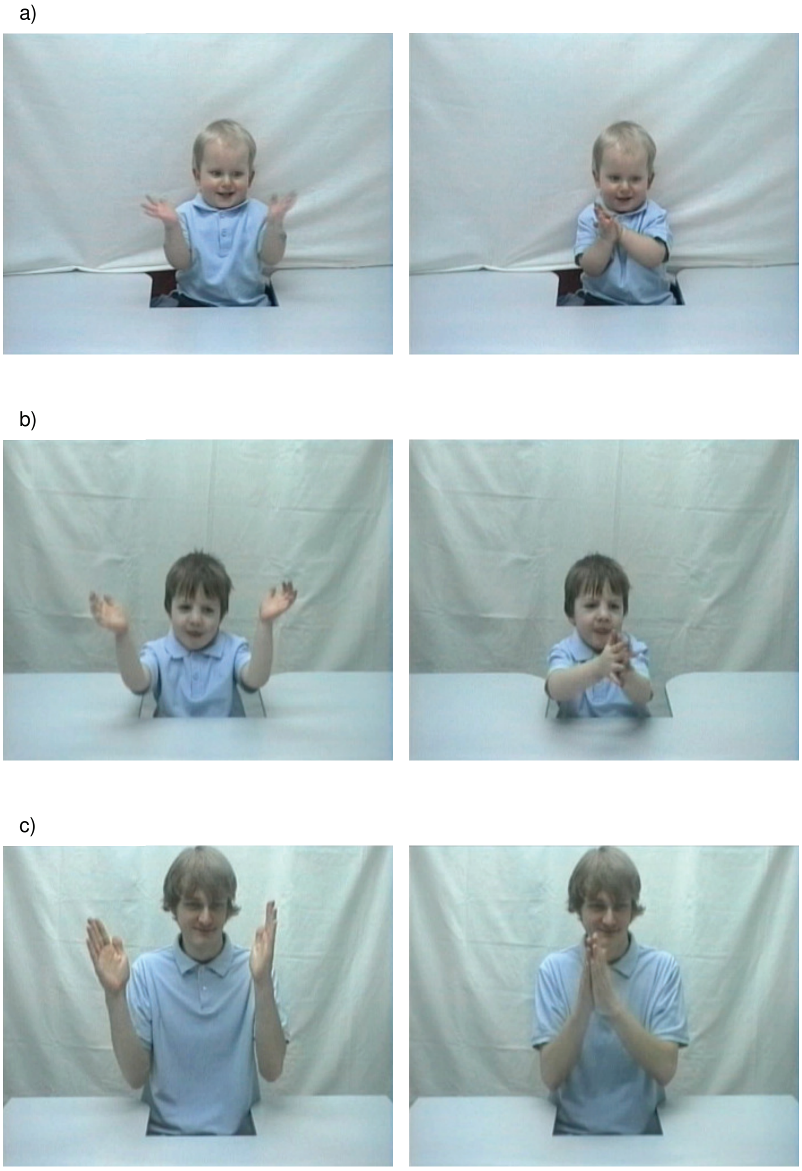

Figure 6. Successive frames of one of the videos (i.e. clapping) for the a) peer model, b) older child model, and c) adult model.

The duration of each video sequence was 25 seconds. Each video sequence presented one of the actions described above. One single body movement was repeatedly presented by playing it on a continuous loop. Speed and sound of the video sequences were edited to ensure a natural appearance of the repeated actions. Consequently, there was no difference in the rhythm or amount of body movements across the three age groups. An audio-visual attention-getter (the same as in Experiment 1) was presented before each video sequence. The model did not talk to the infant, the eyes of the model were not directed towards the camera, and the models' facial expression ranged between neutral and friendly. In contrast to Experiment 1, there was no additional baseline condition as each presentation of a body movement served as baseline for the body movements that were presented subsequently.

3.2.1.3 Procedure

The testing procedure was identical to Experiment 2a, except that in Experiment 2b the demonstration phase and testing phase coincided and infants received no lamp.

3.2.1.4 Data Analysis

Infants' behaviour and looking time during the observation of the video sequences were coded from video by a trained observer who was blind to the condition. An action was coded as one of the four target actions, if it met the following criteria: banging simultaneously with both hands on the table at least once (*Banging*), moving the finger up and down with one hand at least once (*Waving),* clapping with both hands at least once (*Clapping*), touching the mouth with the hand at least once (*Hand-to-mouth).* Additionally, infants had to watch either the monitor or the own hands while performing the action. A second independent observer rated 33% of the videos. Interobserver reliability was .96 (Cohen's kappa) for occurrence of the target body movement. We coded which body movements the infants performed whilst watching the video sequences; therefore infants could have performed a body movement before, during or after the corresponding video sequences were presented on the monitor. For the subsequent analysis we used the trials before the demonstration of a target body movement on the monitor as a baseline phase and the trials during the demonstration of a target body movement as an imitation phase. For the baseline measure, each infant received a score from 0 to 3 for the number of body movements that he or she performed in all trials before the demonstration of the target body movement excluding the body movement that was currently being demonstrated. This score was converted to a percentage of body movements (e.g., 0%, 33%, 67%, or 100%). For the imitation measure, each infant received a score from 0 to 4 for the number of body movements that were copied during their demonstration. This score was converted to a percentage of body movements (e.g., 0%, 25%, 50%, 75%, or 100%). Imitation score and looking time were analysed by performing ANOVAs. If significant differences were found pairwise comparisons were performed using *t*-tests.

3.2.2 Results and Discussion

A 2 x 2 (Phase x Condition) repeated measures ANOVA was performed on the imitation scores with Phase (baseline phase and imitation phase) as within subjects factor and Condition (peer, older child, and adult model) as between subjects factor. This analysis revealed a significant main effect for Phase, $F(1, 33) = 27.48$, $p < .001$, and a marginal main effect of condition, $F(2, 33) = 2.81$, $p = .07$, indicating that infants copied the action that they observed on the monitor and that infants tended to differentiate between the differently aged models. These main effects were qualified by a Phase x Condition interaction, $F(2, 33) = 5.41$, $p = .01$. To further explore the interaction, planned comparisons in the baseline phase and in the imitation phase were conducted. This analysis revealed that in the imitation phase, infants imitated the peer model more often than the older child model, $t(22) = 2.89$, $p = .009$, and more often than the adult model, $t(22) = 2.72$, $p = .012$. In contrast, the infants' reaction towards the older child and the adult did not differ (see Figure 7). Additionally, there were no differences in the imitation scores across conditions in the baseline phase (all *t*'s < 1). As in Experiment 2a, infants in all conditions watched the demonstration closely (adult model: 85.3%, *SD* = 10.7%; older child model: 80.0%, *SD* = 6.4%; peer model: 85.6%, *SD* = 11.9%, $F(2, 33) = 1.33$, $p = .28$, ANOVA).

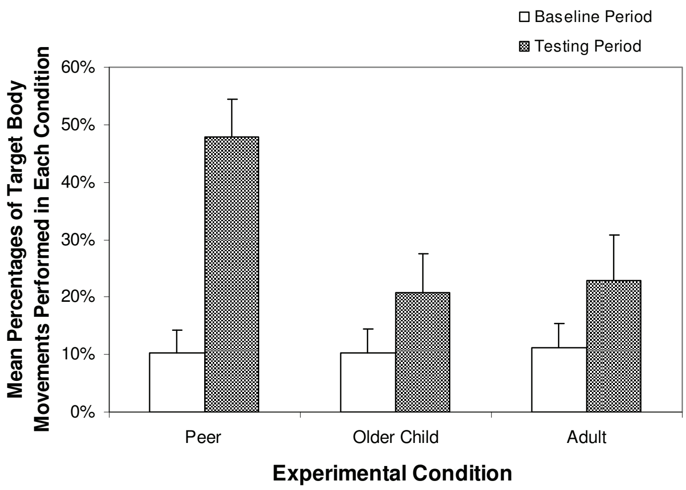

Figure 7. The percentage of trials where infants performed each of the four body movements either before their presentation (baseline period) or during their presentation (testing period). Each bar indicates the standard error.

3.3 General Discussion

In Experiment 2, we investigated the influence of the model's age on infants' imitation depending on whether a novel behaviour (Experiment 2a: head touch) or familiar behaviour (Experiment 2b: body movements) were presented. The results obtained in Experiment 2a showed that the likelihood of imitating a novel action increases as the age of the model increases. This could be interpreted in terms of the cognitive function of imitation: Infants were not only eager to learn a novel action but they selectively imitated the adult model. Therefore, infants might have perceived the adult as a competent teacher when he demonstrated the head touch and they might have assumed that his novel behaviour provides some opaque advantage. In contrast, the head touch demonstrated by the older child and the infant might be interpreted solely as an ineffective way to illuminate the lamp. Along these lines, Csibra and Gergely (2006) suggested in their so called *pedagogy hypothesis* that the transfer of cultural knowledge is across generations, rather than within one generation. In ontogeny, infants are deeply dependent on human culture (Tomasello, 1999). Accordingly, the present finding sheds more light on the impact of knowledgeable adults on the transfer of potentially cultural behaviour.

In contrast to Experiment 2a, Experiment 2b revealed that infants imitate peers more often when presented with familiar behaviour. This result suggests that infants might have used imitation for social reasons in this context. That is, they were more likely to imitate the peer model's behaviour in order to interact with him and share experiences (Eckerman et al., 1989). As there is evidence that infants prefer peers (Bahrick et al., 2002; Bigelow et al., 1990; Greenberg et al., 1973; Lewis & Brooks, 1975; Sanefuji et al., 2005) it is likely that they pursued this preference in a social context like the one in Experiment 2b rather than in a cognitive context like the one in Experiment 2a.

Experiment 2b revealed that similarity between imitator and imitatee with respect to age plays an important role in infant imitation. Piaget (1962) suggested that the similarity of a peer leads to a child's assumption of sharing the same cognitive level from which he or she can learn. Although this might be the case for some aspects (e.g., toy selection) where peers are knowledgeable (VanderBorght & Jaswal, in press), we believe that imitation in infancy happens mostly in adult-infant dyads. Highlighting the importance of similarity more fundamentally, Meltzoff (2005) proposed a "like-me"-hypothesis; infants are born with the ability to imitate, they become aware of the relationship between their own acts and their underlying mental states, and finally, they are capable of attributing mental states to another person who acts "like me". Based on the notion of a fundamental role of similarity between observer and actor in social cognition, Meltzoff and Moore (1997) put forth the idea of common representations for action perception and action production in infants. According to their so called *Active Intermodal Mapping approach*, the tendency to copy an action of another person is based on a common framework for representing the observation and execution of human actions (see also Hommel, Müsseler, Aschersleben, & Prinz, 2001 and Prinz, 1997 for a similar account). An equivalence detector that registers the observed performance of another person and one's own performance is allocated in a supramodal representation of actions. Proprioceptive feedback then allows the matching of one's own behaviour to the observed action. Adult studies have provided evidence for a common representation of action perception and action production (Prinz, 1990; Prinz, 1997). Moreover, brain regions have been identified that are more active when both perceiving and performing actions (for reviews, see Decety & Grèzes, 1999; Fogassi &

Gallese, 2002; Rizzolatti, 2005). Nyström (2008) analyzed the mu-rhythm of infants via EEG during observation of object-directed movements and non-object-directed movements. He reported that the mirror neuron system is already present in 6-month-old infants. This account of imitation relies on actions that are already in the infants' action repertoire (Rizzolatti, 2005). Recent empirical evidence indicates that a common representational system for perception and action might exist by early infancy (Daum, Prinz, & Aschersleben, 2008b; Falck-Ytter, Gredeback, & von Hofsten, 2006; Sommerville & Woodward, 2005; Sommerville, Woodward, & Needham, 2005). Sanefuji et al. (2006b) speculated that it is easier for an infant to imitate a peer than an adult because infants share the same bodily characteristics with their peers. Thus, one might suggest that infants' imitative performance is best when they encounter peers because of the similarity between the observed action of a peer and their own motor repertoire. It is important to note that the suggested mechanism of imitation is not in contrast to the functions of imitation (e.g., a cognitive and a social function of imitation, Uzgiris, 1981). One should be aware that these functions of imitations might modulate infants' imitation depending on the situation. There might not be a direct match between infants' observation and infants' performance.

Accordingly, the results of Experiment 2a cannot be fully explained by only referring to common representations of action perception and action production because infants imitated the model that was most dissimilar to them. Brass, Schmitt, Spengler, and Gergely (2007) conducted an fMRI study in which they investigated action understanding in novel situations. Their study included two conditions that were analogous to the head touch task of Gergely et al. (2002): Brass et al. (2007) demonstrated novel actions (e.g., operating a light switch with the knee) either when the hands were free or when the hands were occupied (e.g., by holding a couple of folders). They could show that action understanding is mediated by brain regions that are involved in inferential processes but that are not part of the mirror-neuron circuit. At first glance, their finding is in contrast to recent studies showing an involvement of the mirror neuron circuit in action understanding (Iacoboni et al., 2005; Rizzolatti & Craighero, 2004). Brass et al. (2007) highlighted that this is probably due to the novel actions that they demonstrated. These actions were not in the action repertoire of the participants and therefore a mapping between observed actions of others and own actions was not possible. Thus, participants had to evaluate the efficiency of the action with respect to the situational constraints. This study provides further evidence that imitation of novel behaviour (as in Experiment 2a) might be processed differently than familiar behaviour (as in Experiment 2b).

However, one should interpret the present findings cautiously due to the applied methods. First, there might have been a less social nature of televised models as compared to live models. As discussed in chapter 1.2.4, young children perform worse in imitation studies where the stimulus behaviour is presented by a televised model compared to their performance when the stimulus behaviour is presented by a live model. However, it has been recently shown that 12-month-olds are not severely impaired in imitating a televised model (Barr, Muentener, & Garcia, 2007). Second, Experiment 2a and Experiment 2b did not only differ with respect to the familiarity of the behaviour (novel vs. familiar), but also with respect to time when imitation was coded (after demonstration vs. during demonstration) and type of action (object directed action vs. body movement). There is no reason to explain the differential findings of Experiment 2a and Experiment 2b based on these additional differences. However, the findings of Experiment 2 would be even more convincing if they were found with analogous methods.

To summarise, Experiment 2 revealed that infants differentiated in their imitative behaviour between the models' age. Moreover, this differentiation varied depending on the familiarity of the behaviour. On the one hand, the likelihood of imitating a novel behaviour increases as the age of a model increases, on the other hand, infants imitated predominantly from the peer model when the behaviour was familiar. These data suggest that 14-month-olds flexibly use imitation for two distinctive reasons: If infants encounter an adult who is perceived as competent, the adult provides a context of learning in which the infants adapt novel skills. In contrast, if infants encounter a peer, the peer provides a context of nonverbal interaction in which infants use imitation to communicate.

4 Experiment 3: Infants' Re-Enactment of Full Demonstrations and Failed Attempts Performed by Differently Aged Models

As noted above, Experiment 2a and Experiment 2b did not only differ with respect to the familiarity of the behaviour (novel vs. familiar), but also with respect to time when imitation was coded (after demonstration vs. during demonstration) and type of action (object directed action vs. body movement). These additional factors were controlled for in the first part of Experiment 3. Infants were presented with an imitation task including full demonstrations of an object-directed actions (adapted from Meltzoff, 1995, and Johnson et al., 2001). We assumed that the actions (e.g., putting an object into a cup) are familiar to the infant. Accordingly, we presented infants with object-directed actions (analogous to Experiment 2a) that represented familiar behaviour (analogous to Experiment 2b) performed by differently aged models.

Furthermore, in the second part of Experiment 3, we were interested whether younger models enhance the understanding of goals in 14-month-olds. Usually, the intended goal of an actor and the result of an action coincide. However, those cases were the intended goal and the result diverge are most informative to test whether infants are able to infer another person's goal. As noted in chapter 1.2.1, Meltzoff (1995) extended the scope of the imitation paradigm: he investigated via a behavioural re-enactment method how infants react to an adult who tried, but failed, to perform an action: do they blindly copy the surface behaviour or do they re-enact what the adult intended to do? His study revealed that 18-month-old infants are able to re-enact the desired goal of a failed attempt. In subsequent studies that applied analogous tasks it was shown that the ability to re-enact intended but unfulfilled goals is present in 15-month-olds but not in 12-month-olds (Bellagamba & Tomasello, 1999; Johnson et al., 2001). Analogous to previous studies on re-enactment on failed attempts, the models in the second part of Experiment 3 tried but failed to perform the target action.

For the conditions where the differently aged models demonstrated the complete target action (full demonstration conditions), we hypothesised that peer models are imitated more often than adult models (as in Experiment 2b). For the conditions where the models tried but failed to perform the target act (failed attempt conditions), the hypothesis were less clear. First, we were not sure whether 14-month-olds are capable of re-enacting failed attempts at all. Second, if 14-month-olds are capable of re-enacting failed attempts, infants might be more likely to re-enact what the peer models intended to do in order to interact with them (analogous to Experiment 2b). Alternately, they might be more likely to re-enact what the adult models intended to do because infants might interpret adult behaviour as more intentionally than peer behaviour. Analogous to Experiment 1 and Experiment 2, we used televised models.

4.1 Method

4.1.1 Participants

Participants were one hundred and five 14-month-olds (*M* = 13;27, range 13;15 to 14;15; 47 girls, 58 boys). Twenty-six additional infants were tested, but not included in the final sample due to fussiness, lack of interest in the video stimuli, procedural errors, or refusal to touch the test objects.

4.1.2 Test Environment and Material

The technical equipment as well as the test environment was identical to Experiment 1. We used a split screen generator to record both, a close-up view of the infant from a camera was positioned above the monitor and a copy of the demonstrated video sequences.

Five set of objects were used as test stimuli (see Figure 8). The sets were adapted from Meltzoff (1995) and Johnson et al. (2001). The first object was translucent box (10 x 10 x 10 cm) with a round hole (3cm diameter, 7 cm length) on the middle of the top surface. The back side was covered with a blue self-adhesive film. A red octagonal stick (2cm diameter; 14 cm length) could be inserted in the hole. The second set of objects was a wooden dumbbell shaped object. Two red wooden cubes (4 x 4 x 4 cm) were attached to both ends of a blue stick (14 cm length; 2 cm diameter). One of the cubes could be pulled apart from the stick. The third set of objects was a green prong (3.5 cm diameter; 6 cm length) that was attached to blue board (20 x 15 cm) and a loop that consisted of white and red wooden beads with a diameter of 10 cm. The fourth set of objects consisted of a translucent cylinder (11 cm height; 10 cm diameter) and a string (15 cm length) made of blue wooden beads. The backside of the cylinder was covered with a yellow self-adhesive film. The fifth set of objects was yellow plastic column (16 cm height; 3 cm diameter at the top) attached on a blue plastic board (12 x 12 cm). A red plastic cup (5 cm height; 6 cm diameter) that has no bottom could be put over the column.

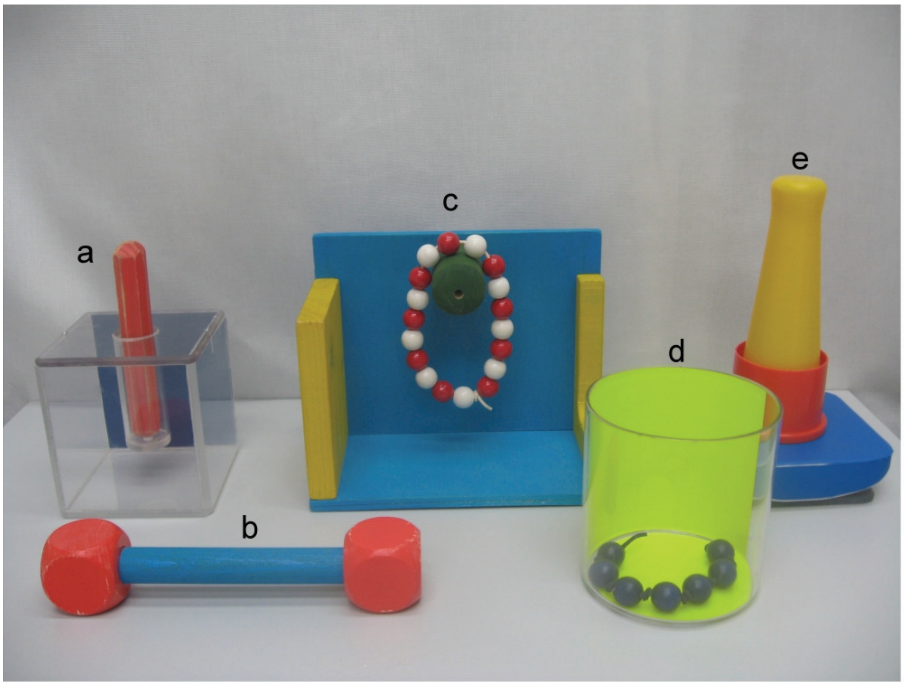

Figure 8. The five sets of objects: a) box and stick, b) dumbbell, c) prong and loop, d) cylinder and beads, and e) column and cap

4.1.3 Stimuli

There were three different age groups that demonstrated the target acts: peers (14-month-olds), older children (3.5-year-olds), and adults (20- to 25-year-olds). Each model age group consisted of five models. All models were male. Infants were randomly assigned to one of seven conditions with 15 infants in each condition. There were three conditions where the models demonstrated the complete target action: (1) full demonstration peer, (2) full demonstration older child, (3) full demonstration adult.

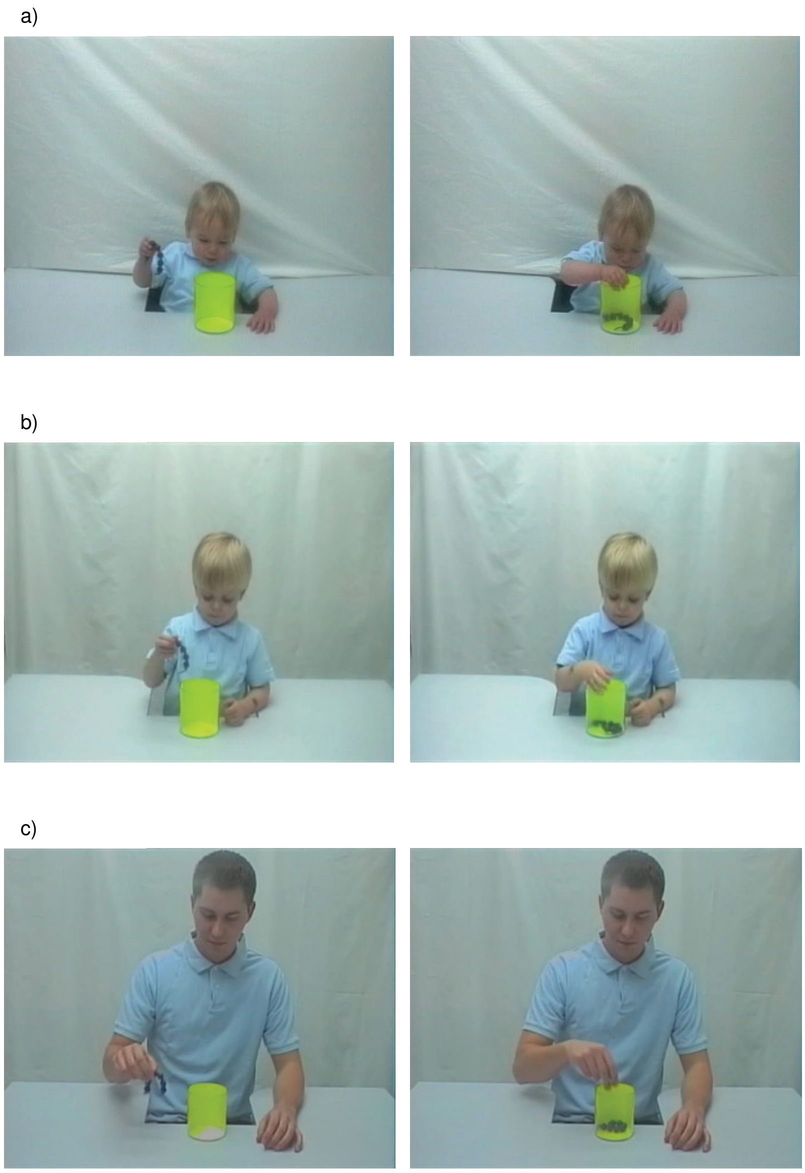

Figure 9. Successive frames of one of the videos (i.e., cylinder and beads) in the full demonstration condition for a) the peer model, b) the older child model, and c) the adult model.

There were also three conditions where the models demonstrated the unsuccessful trial of the target action: (4) failed attempt peer (5) failed attempt older child (6) failed attempt adult. A seventh group of infants received no prior demonstration of an action (baseline condition). The order of presentation of the five different set of objects was counterbalanced.

one hand while the other hand held the other part of the dumbbell. For the prong and loop, the model took the loop and draped it over the prong so that the prong protruded the loop. For the cylinder and beads, the model took the beads and placed it into the cylinder (see Figure 9). For the column and cap, the model raised the cap, placed it on the column, and lowered the cap until it reached the bottom board.

Failed attempt. In these conditions, the model did not demonstrate the target actions fully. In contrast to the full demonstration conditions, the model attempted to produce the final end state but he failed. For the box and stick, a translucent plastic disk was placed in the whole beforehand in order to ease the production of failed attempts in the failed attempt peer condition. The older child model and the adult model faced the same constraint. The model took the stick, then he tried to insert it in the hole, and finally he slipped so that the stick slipped of the top panel of the box. Note, that the models tried to insert the stick a little aside from the disk covering the hole. For the dumbbell, a second identical dumbbell was prepared except that both cubes were fixed. The model took the dumbbell, tried to pull one cube apart, and then the hand that pulled the cube slipped off the cube. For the prong and loop, the model tried but failed to put the beads over the prong. The model raised the loop and directed the opening of the loop towards the prong. However, he missed the prong by a few centimetres. For the cylinder and the beads, the top of the cup was covered by a translucent plastic panel. The model took the beads and raised them. Then, he dropped the beads above the edge of the cup, so that the beads fell on table. Note, that the beads did not fall directly on the panel covering the cup. For the column and cap, both openings of the cap were covered by two translucent plastic panels. The model raised the cap and held it over the column. Then he failed to put on the column because they lowered the cap a little too far to the side.

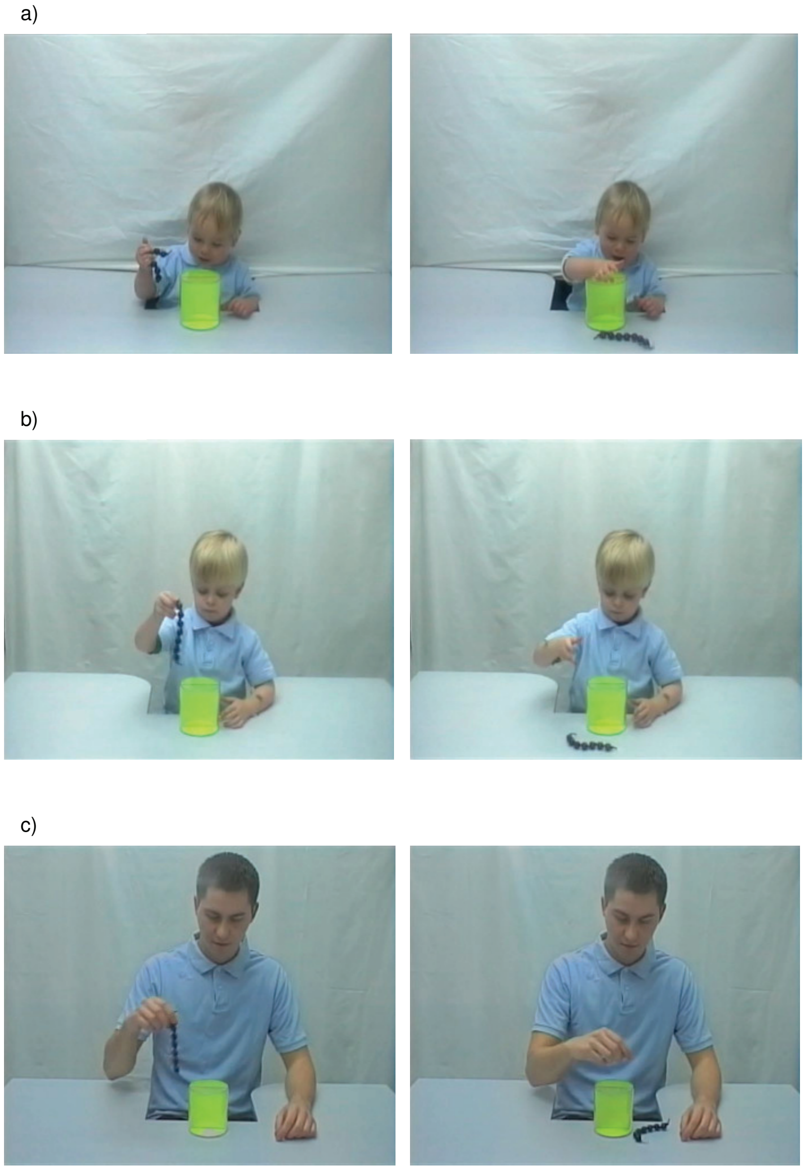

Figure 10. Successive frames of one of the videos (i.e., cylinder and beads) in the failed attempt condition for a) the peer model, b) the older child model, and c) the adult model.

The warm-up phase before parents and infants were brought to the test room was identical to the previous Experiments. As soon as the parent and the infant sat in front of the monitor, the experimenter hid behind a curtain. A second experimenter then started the corresponding video sequence.

Infants were randomly assigned to one of seven conditions. Infants in all seven conditions first observed the televised set of objects for 5 seconds and heard a male voice say, “Look, there!” In the full demonstration conditions and in the failed attempt conditions, infants then viewed the target acts. For a particular age group, each model was assigned to one of the five set of objects. For each set of objects, a video sequence consisting of three slightly different actions was prepared. This sequence was repeated once, so that infants perceived six demonstrations of a target act. At the beginning of each single action, an attention-getter was presented on the screen (identical to the one used in Experiment 1). Duration of the presentations in both condition and each age group was approximately 50 seconds.

After the demonstration of each video sequence consisting of the six target acts, the screen turned black, the experimenter appeared and placed the corresponding set object of objects in front of the infant saying “Now you can play with it!” Then, the experimenter hid again behind the curtain. The 20s response period started from the moment the infants first touched the object. The objects were never available during the presentation of the video sequences and only one object at a time was present during the response period.

4.1.4 Data Analysis

An observer who was blind to the condition coded the amount of time infants focussed on the televised demonstration. Additionally, infants’ actions were scored that happened during a 20s response period starting from the moment the infant touched the test object. Infants were scored as having produced a target action if the actions met the following criteria:

Box and stick. The infant inserted the stick into the box at least for approximately 1 cm.

Dumbbell. The infant’s action resulted in separating the wooden cube from the dumbbell.

Prong and loop. The infant placed the loop over the prong so that the prong juts out the loop.

Cylinder and beads. The infants put the beads into the cylinder so that the beads touch the bottom of the cylinder.

Column and cap. The infant lowered the cap over the end of column so that the column protrudes the cap.

A second independent observer rated 33 % of the videos. A good level of reliability was achieved for the mean number of target actions (.90; Cohen's kappa).

Because of the deviance of the mean number of target actions from the normal distribution in the full demonstration conditions, the data were analysed non-parametrically. For both, the three full demonstration conditions (peer, older child, and adult) and the three failed attempt conditions (peer, older child, and adult), the mean number of target actions were compared by performing Kruskal-Wallis tests. If significant differences were found pairwise comparisons were performed using Mann-Whitney *U*-tests. For the looking time data, only the looking times in the full demonstration conditions deviated from the normal distribution. Accordingly, looking times in the full demonstration condition were analysed non-parametrically (Kruskal-Walli tests) and looking times in the failed attempt conditions were analysed parametrically (ANOVA). All statistical tests were two-tailed.

4.2 Results

Across the three full demonstration conditions, infants differed in mean number of target actions, χ^2 (2, N = 45) = 8.27, p = .016, Kruskal-Wallis test, see Figure 11. Subsequent Mann-Whitney *U*-tests revealed that peers were imitated more often than older children (U = 47.0, p = .005) and adults (U = 64, p = .042). However, there was no difference between the imitation of older children and adults (U = 98.0, p = .54). Pairwise comparisons between the three full demonstration conditions and the baseline condition showed that infants imitated peers above baseline level (U = 43.5, p = .009, Bonferroni correction). In contrast, infants' imitation of the demonstrated target acts did not differ from the baseline condition when older children or adults performed the actions (U = 105.0, p = .74; U = 101.0, p = .63, respectively).

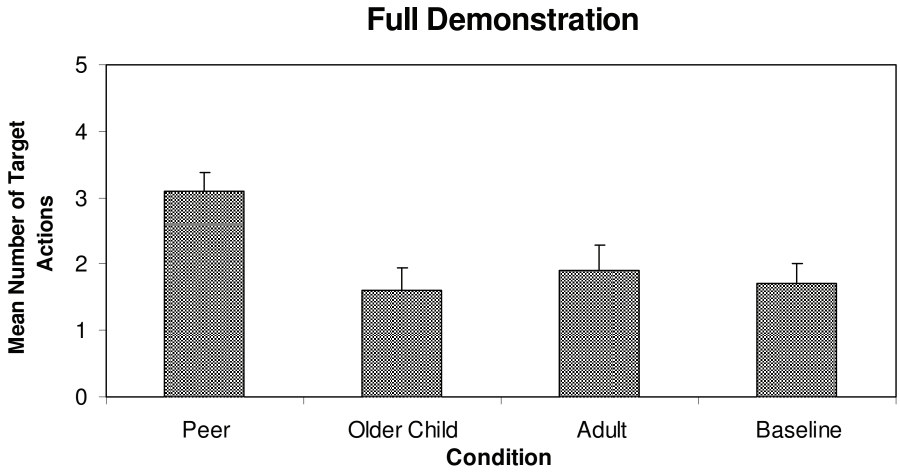

Figure 11. Mean number of target actions in the full demonstration condition for each model age group and the baseline. Each bar indicates the standard error.

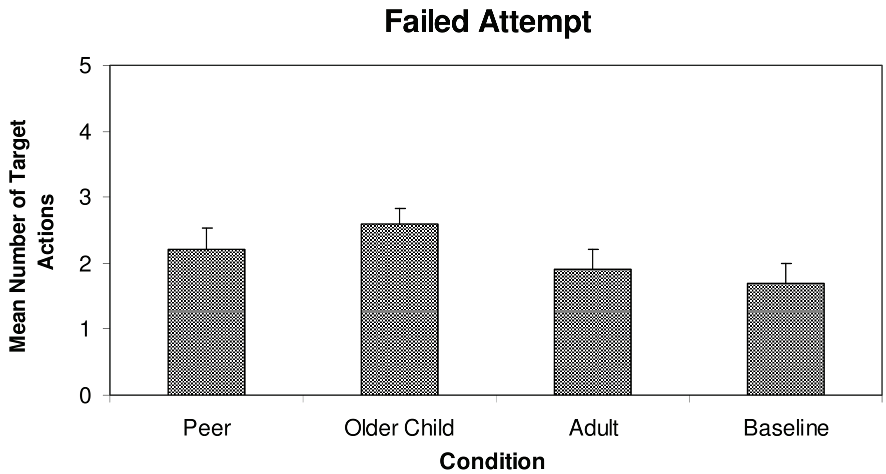

Figure 12. Mean number of target actions in the failed attempt condition for each model age group and the baseline. Each bar indicates the standard error.

Infants that observed the failed attempts did not differ their mean number of target actions, χ^2 (2, N = 45) = 2.46, p = .29, Kruskal-Wallis test, see Figure 12. Moreover, pairwise comparisons between the three failed attempt conditions and the baseline condition revealed that infants did not re-enact the target actions above baseline level in neither condition (peer model: *U* = 86.5; *p* = .78; older child model: *U* = 80.0; *p* = .08; adult model: *U* = 97.5; *p* = 1.0; Bonferroni correction).

Note that infants in all conditions infants spent looking at the demonstration more than 80% of time. There were no significant differences in looking times between the full demonstration conditions (peer model: 89.7%, *SD* = 6.3%; older child model: 87.7%, *SD* = 7.6%; adult model: 82.3%, *SD* = 10.7%, χ^2(2, *N* = 45) = 4.20, *p* = .12, Kruskal-Wallis-test). However, there was a marginal difference in looking times between the failed attempts conditions (peer model: 88.6%, *SD* = 7.9%; older child model: 86.2%, *SD* = 9.6%; adult model: 81.3%, *SD* = 8.2%, *F*(2, 42) = 2.83, *p* = .07, ANOVA). Subsequent post-hoc tests for the failed attempt conditions with Bonferroni correction revealed that that infants tended to look longer to peer models than to adult models (p = .07). However there was no difference between the looking times neither to peers and older children (*p* = 1.0) nor to older children and adults (*p* = .38).Overall, there was a numerical trend towards increasing looking times with decreasing age of the models. This trend, however, did not reflect the performances in the imitation tasks because there was no correlation between looking time and imitation score (r = .00, *p* = 1.0*,* Pearson correlation).

4.3 Discussion

In Experiment 3, we raised two questions. First, are infants more likely to imitate peer models than older child models or adult models when presented with familiar complete object-directed behaviour? Our results show that 14-month-olds indeed imitate their peers more often than older children or adults if the actions are demonstrated fully. Second, is infants' re-enactment of failed attempts influenced by a model's age? Apparently, 14-month-olds were not able to re-enact the failed attempts of neither model age group.

The finding in the full demonstration peer condition is consistent with previous studies showing that infants do imitate their peers (Eckerman et al., 1989; Hanna & Meltzoff, 1993; Ryalls et al., 2000) and that they imitate familiar body movements more often from peers than from older models (Experiment 2b). In several studies it has been highlighted that infants use imitation in order to communicate with their peers

(Eckerman et al., 1989; Eckerman & Whatley, 1977; Nadel-Brulfert & Baudonnière, 1982). Analogously, it is likely that infants imitated peer models in the full demonstration condition more often than older children or adults for social motives. That is, infants might have related their behaviour to peers in order to achieve social coordination or to affiliate with them.

At first glance, in the full demonstration condition, we could not replicate an advantage in the imitation task of an older child model compared to an adult model as reported by Ryalls et al. (2000). However, Ryalls et al. (2000) did not report that observing an older child model resulted in an increased number of imitative acts as compared to observing an adult model. They only stated that infants exposed to an older child model showed more ability to perform the target event sequences correctly as compared with infants exposed to an adult model. The target event sequences consisted of three-step events (e.g., first, putting a teddy into bed, second, covering teddy with a blanket, and third, rocking the cradle). In Experiment 3, we presented only single-event actions and therefore we could not perform an analogous test.

The present results in the full demonstration adult condition are somewhat contradictory to the finding of Huang and Charman (2005) that 17-month-olds happily imitated televised adults performing actions that were similar to the target actions of Experiment 3. However, in their study, infants only observed the torso and the hands of the model but not the face and the model demonstrated the actions in a slow and instructive style. In contrast, in the present experiment, infants observed the whole upper body of the model including the face and they watched the models performing the actions in a lifelike style without a slow down of the movements. Huang and Charman's (2005) demonstration in slow-motion with a focus on the action might facilitate attending to and copying the relevant behaviour. Furthermore, the infants in their study were 17 months of age, whereas the infants in our study were only 14 months of age. Since imitative abilities increase rapidly during the second year of life (Jones, 2007), it is likely that 17-month-olds are better re-enactors in this task than 14-month-olds. Accordingly, the differences in the stimuli set as well as the participants' age difference of 3 months could have resulted in a lack of imitation in the full demonstration adult condition.

In contrast to the selective imitation of the peer models in the three full demonstration conditions, infants in the three failed attempt conditions did not discriminate between the different age groups in their imitative performance. Moreover, the mean number of target actions in the failed attempt conditions did not differ significantly from the mean number of target actions in the baseline condition. There might have been several reasons for this negative finding. First, previous research on the re-enactment of failed attempts (Bellagamba & Tomasello, 1999; Johnson et al., 2001) suggested that this ability emerges between 12 and 15 months of age. Therefore, 14-month-olds in our study might not have been able to re-enact the models' intended acts. Note, that there is recent evidence that infants of 10 months of age (Legerstee & Markova, 2008) and 7 months of age (Hamlin et al., 2008) are able to re-enacted failed attempts. However, in these studies simpler target actions were used. Second, different to previous studies on re-enactment of failed attempts in infants around 14 months of age (Bellagamba & Tomasello, 1999; Johnson et al., 2001), we used televised instead of live models. Huang and Charman (2005) included televised models in their study and they reported that 17-month-olds re-enacted failed attempts. However, as noted above, their study differed from the present one in several aspects (e.g., visbility of the model's face, velocity of the demonstrated target act, and particpants' age). Some authors (e.g., Anderson & Pempek, 2005, and Barr et al. 2007) argued that using televised models bears the risk of making a task more difficult for infants than using live models. However, Barr et al. (2007) also reported that learning of 12-month-olds was not severely affected by the video method when the number of demonstration trials was increased from 3 to 6 repetitions compared to a condition were the actions were demonstrated 3 times by a live model. In the present study the target acts were presented 6 times. However, to our knowledge, it has not been investigated yet whether increasing the number of demonstrations also ameliorates infants' performance in a re-enactment task of failed attempts. Therefore, the video method still might have contributed to the negative finding. Third, in previous analogous studies the mean percentage of target actions in the baseline condition was low (Bellagamba & Tomasello, 1999, *M* = 18%, *SD* = 18%, for 12-month-olds, and Johnson et al., 2001, *M* = 10%, with no *SD* given, for 15-month-olds). In contrast, infants in the present experiment performed the target action numerically more often in the baseline condition (*M* = 34%, *SD* = 24%). The high percentage of target actions in our baseline condition might have obscured infants' ability to re-enact failed attempts.

It is noteworthy that infants tended to spend more time observing peers than adults in the failed attempt condition. In some studies using pictures as stimuli similar results were reported. McCall and Kennedy (1980) reported longer looking times of 4-month-olds to peer faces as compared to faces of older models. Lewis and Brooks (1975) reported that 16- to 18-month-olds showed more positive behavioural responses such as smiling and vocalization when viewing peers. More recently, Sanefuji et al. (2005) analysed the duration of 7-month-olds' first look to video stimuli of peers, older children, and adults. They reported that infants' first look was longer to peer models as compared to older child models. In contrast, Zmyj, Daum, Prinz, & Aschersleben (2008) found an opposite effect in 12-month-olds when analysing mean looking times to video stimuli of peers, older children, and adults. However, in both studies (Sanefuji et al., 2005; Zmyj et al., 2008) models were presented that played with an object and that did not perform failed attempts. Since it is difficult to integrate the present finding into the findings of previous studies, one could speculate that the present failed attempt videos might have been slightly different. That is, the accidents of the peer models happened naturally whereas the failed attempts of child and adult models were instructed. Therefore, the peer models might have been slightly more interesting. In any case, there was no association between mean looking time and imitation score on both, individual and group level. On individual level, the correlation between mean looking time and imitation score was zero. On group level, infants imitated the action in the full demonstration condition more often from peers than from older models although there were no differences in looking times to the video sequences of the differently aged models. Moreover, infants showed no significant difference in the mean number of target actions in the failed attempt condition although they spent more time looking at the video sequences of peers as compared to the video sequences of adults.

To summarise, we could clarify and extend previous studies on peer imitation. We showed that 14-month-olds are more likely to imitate peers than older children or adults when presented with complete familiar object-directed actions. In light of the results of Experiment 2b, there is no indication that type of action or time of coding influenced the increased likelihood of imitating peers. However, this effect seems to be limited - at least in 14-month-olds - to complete actions of others and does not extend to failed attempts.

5 Experiment 4: The Reliability of a Model Influences 14-Month-Olds' Imitation

Imagine watching as a stranger approaches a novel box and – instead of pushing it with his hand – sits on it to turn on a light inside. Would you copy this novel action when interacting with the box yourself? You might, if the stranger had acted confidently and you knew from previous experience that he was knowledgeable about these types of boxes; you might not if first he had inspected the box uncertainly or if he had shown you by his previous actions that he was an unreliable model. When we learn from others it is important to take into account their competence as a model, and copy their actions selectively depending on how reliable or knowledgeable they are.

In Experiment 2a, infants imitated the novel head touch more likely if an adult model demonstrated the action as compared to younger models. We suspected that infants evaluate adults as more competent than children or infants when acting on novel objects. We used a new, nonverbal paradigm to directly investigate whether the reliability of a model influences infants' imitative behaviour. In order to explore the extent of this effect we included not just imitation tasks but also preference tasks, to contrast learning about conventional versus more idiosyncratic types of information. For both types of tasks, infants first were shown a series of videos in which a model acted on various familiar objects either competently (reliable condition) or incompetently (unreliable condition). Then infants watched as that same model neutrally demonstrated a novel action on an object (imitation tasks) or interestedly chose one of two novel objects to keep (preference tasks). We predicted that infants would copy the novel action in the imitation tasks more often after having watched the model act reliably than after having watched him act unreliably previously. For the preference tasks, the prediction was less clear as infants might regard preferences as individual dispositions that are not affected by one's competence and/or are not meant to be copied.

5.1 Method

5.1.1 Participants

Sixty-four 14-month-olds (*M* = 14;0; range 13;15 to 14;15; 34 girls, 30 boys) participated in the study. Nine additional infants were tested but not included in the final sample due to fussiness. Infants were recruited from a database of parents who had agreed to participate in child development studies.

5.1.2 Design

The experiment consisted of two imitation tasks and two preference tasks, presented blocked and in fully counterbalanced order. Half the infants participated in each of the four tasks in the reliable condition and half in the unreliable condition.

5.1.3 Test Environment and Materials

The test environment and the technical equipment were identical to the previous experiments. For one of the *imitation tasks*, the *head touch task*, a round lamp (12 cm diameter) mounted on a black rectangular board (27 x 20 cm) was used. The lamp could be illuminated by pressing on the top (as in Meltzoff, 1988b). Two versions of the lamp were used: for the video sequences, the board to which the lamp was attached was horizontally oriented but for infants it was tilted by 30° to facilitate head touches. For the other *imitation task*, the *sit touch task*, a rectangular plexiglass box (60 x 22 x 14 cm) with six small differently coloured lamps inside was used (as in Buttelmann, Carpenter, Call, & Tomasello, 2007). The lamps could be illuminated by pressing on top of the box.

Four novel objects were used in the *preference tasks*. For one of these tasks the objects were a yellow octagonal box (12 x 12 x 12 cm) and a pink cylinder (9 x 14 cm). For the other task the objects were a blue cone (10 x 25 cm) and a green ellipsoidal box (15 x 12 x 8 cm).

5.1.4 Procedure

The general procedure was as follows: for each of the imitation and preference tasks (see below), first, all infants watched a series of three familiarization videos, in either the reliable or the unreliable condition, then all infants watched the same, neutral test video. Infants were then given the object(s) from the test video to interact with themselves.

For both types of tasks, the model's reliability or unreliability was expressed in two ways: 1) in the model's choice of correct versus incorrect body parts or objects to use and 2) in the certainty or uncertainty he expressed while making this choice. Thus, in the reliable condition, prior to each action in the familiarization videos, the model looked at the camera, then at the object(s), and then illustrated his certainty by holding up both hands, making a confident facial expression, and saying, "Ah!". In the unreliable condition, in contrast, at the same points in the procedure the model illustrated his uncertainty by holding up both hands, palm up, making an unsure facial expression, and saying, "Hm." See Figure 13 and Figure 14 for a depiction of these expressions. At the beginning of each video in both conditions, an attention-getter (the same as in the previous experiments) was presented on the screen. Note that all actions in both conditions were demonstrated by the same male model.

In order to match the context of the familiarization videos to their respective test videos – that is, to give infants the best chance to see the connections between them – slightly different types of actions were shown in the imitation and preference tasks, as follows.

Imitation tasks: Familiarization videos for the imitation tasks each consisted of the model using a familiar object with either the correct or an incorrect body part, depending on the condition. For example, first, the model looked at the camera and announced that he wanted to put on sunglasses. In the reliable condition he proceeded to put the sunglasses on his face but in the unreliable condition he put them on his foot. See Table 2 for a list of all the actions modelled in the imitation tasks.

Table 2. *The Actions Shown in the Familiarization and Test Phase of the Imitation Tasks in Each Condition*

Familiarization phase	*Condition*	
	Reliable	*Unreliable*
Putting a shoe on the…	Foot	Hand
Putting a glove on the…	Hand	Foot
Telephoning with the…	Ear	Top of the head
Putting a hat on the…	Top of the head	Ear
Kicking a ball with the…	Foot	Nose
Putting sunglasses on the…	Nose	Foot
Test phase		
Sit touch task: Turning on a light by sitting on it		
Head touch task: Turning on a light with the forehead		

Then, after each series of three familiarization videos, infants in both conditions watched the same test video. In each test video, the model first looked at the camera with a neutral facial expression, then silently used an unusual novel action to turn on the lamp, and looked back up to the camera neutrally. In the head touch task, the model touched his forehead to the lamp three times, illuminating the lamp briefly each time (as in Meltzoff, 1988b). His hands rested naturally on the table next to the lamp. In the sit touch task, the model sat three times on the box, illuminating the lamps briefly each time (as in Buttelmann et al., 2007). Figure 13 shows successive images extracted from one familiarization video and one test video. When the test video ended, an experimenter (a different male adult) entered the room, placed the apparatus from the video either on the table (head touch) or the floor (sit touch), told infants, “Now you can play with it!” and left the room. The length of the response period varied by task due to differing interest and difficulty levels for each apparatus: it was 60 seconds for the head touch task and 120 seconds for the sit touch task, starting from the moment infants first touched the apparatus.

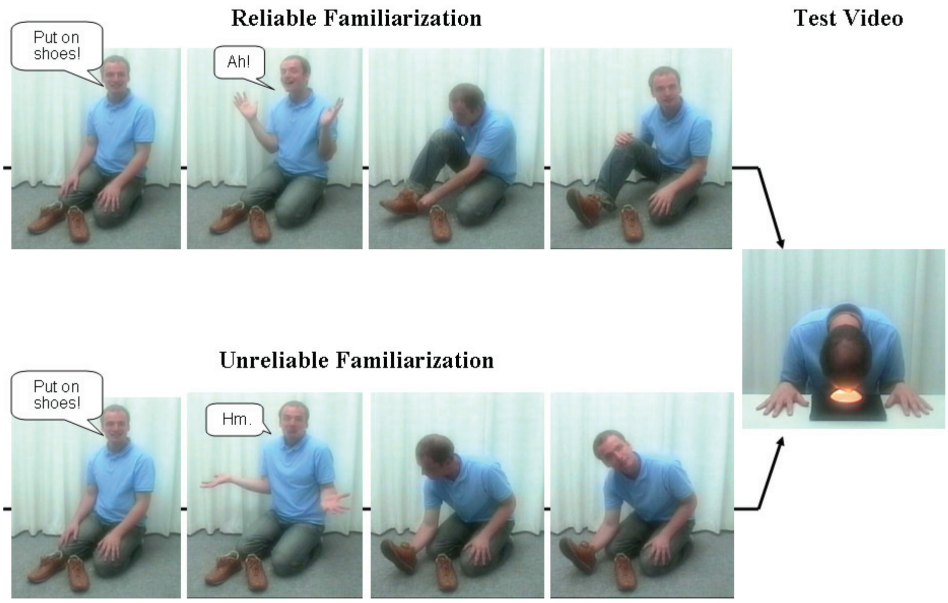

Figure 13. Successive frames from the videos of one of the imitation tasks for the reliable and unreliable condition.

Preference tasks: Familiarization videos for the preference tasks consisted of the model choosing either the correct or an incorrect object with which to achieve a goal. For example, the model looked at the camera and announced that he would brush his hair, then did so either with a hair brush (reliable condition) or a spoon (unreliable condition). In both conditions, the hair brush and the spoon were located on the table the model was sitting at. One object was on the model's left side and the other object was on his right side. The side that the chosen object was on was counterbalanced. See Table 3 for a list of all the actions modelled in the preference tasks.

Table 3. *The Actions Shown in the Familiarization and Test Phase of the Preference Tasks in Each Condition*

Familiarization phase	*Condition*	
	Reliable	*Unreliable*
Drying hands with a…	Towel	Cap
Putting a … on the head	Cap	Towel
Eating pudding with a…	Spoon	Hair brush
Brushing his hair with a…	Hair brush	Spoon
Telephoning with a…	Mobile phone	Toy car
Driving with a…	Toy car	Mobile phone
Test phase		
Blue cone and green box task: Chose blue cone or green box		
Pink cylinder and yellow box task: Chose pink cylinder or yellow box		

Then, after each series of familiarization videos, infants in both conditions watched the same test video of the model choosing one of two novel objects (as in Thomas, Due, & Wigger, 1987). In each of these test videos, the model first looked at the camera with a neutral facial expression, then looked at each object in turn (in counterbalanced order), and then chose one of the objects by picking it up and looking at it from different angles with a happy, satisfied facial expression while nodding his head. He then held it up to his cheek, caressed the object while vocalizing lovingly, and looked back at the camera. Figure 14 shows successive images extracted from one familiarization video and one test video. The object the model chose and the side of the chosen object were counterbalanced. When the test video ended, the experimenter entered the room, placed a tray with both of the objects from that video on it (on the same sides as in the video, approximately 30 cm apart) on the table in front of infants, told infants, “Now it’s your turn!”, and left the room. Because infants normally responded very quickly, they were given 30 seconds to choose one of the two objects.

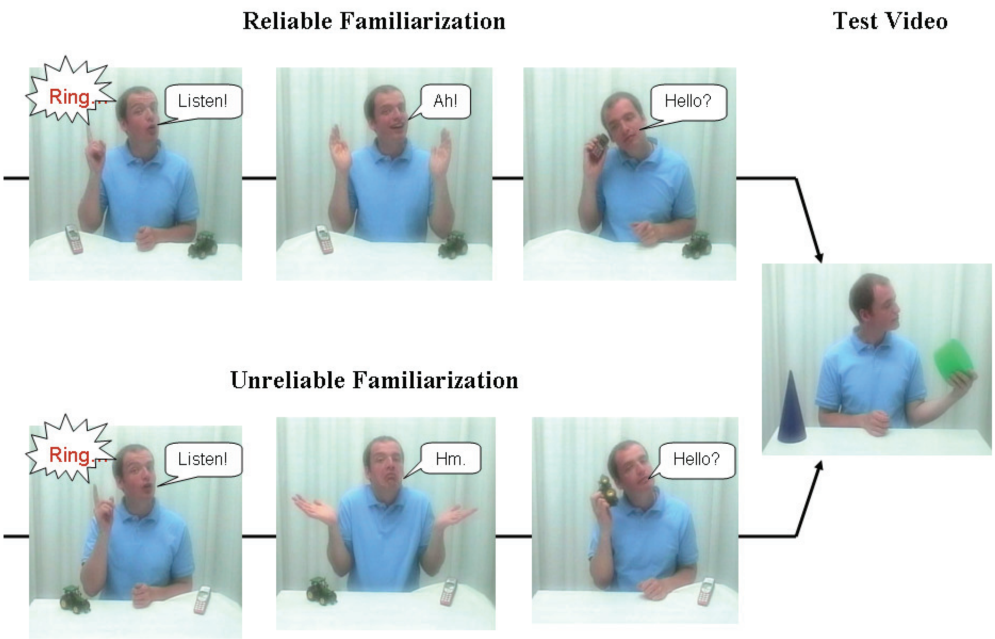

Figure 14. Successive frames from the videos of one of the preferences tasks for the reliable and unreliable condition.

5.1.5 Data Analysis

Infants' behaviour was coded from video blind to condition. In the imitation tasks, infants were scored as having copied the head touch action if they touched the lamp with their head, and as having copied the sit touch action if they turned on the lamps by sitting on the box (or by attempting to do so by putting one leg over it). In the preference tasks, the object infants touched first was coded. For the imitation and the preference tasks separately, infants received a score from 0 to 2 for the number of tasks in which they copied the model's action or chose the same object he did. This score was converted to a percentage because some infants (24 out of 64) did not participate in all trials due to inactivity, inattentiveness, or fussiness (sixteen infants only completed three tasks, six infants only completed two tasks, and two infants only completed one task). To see whether infants paid the same amount of attention to the videos in each condition we also coded the number of seconds infants spent looking at the familiarization videos for each task.

A second, independent observer coded 100% of the trials. Interobserver agreement was excellent: Cohen's Kappa = .93 for the imitation tasks and .90 for the preference tasks. Excellent agreement was also achieved for infants' looking time during the videos (Intraclass Correlation Coefficient, r = .99). Two-tailed p values are reported throughout.

5.2 Results

In the imitation tasks, as expected, infants who had previously watched the model act reliably imitated the novel action more than twice as often as infants who had previously watched the model act unreliably, Mann-Whitney U = 303.0, N = 63, p = .004, see Figure 15. Similar results were found for each imitation task separately: in the head touch task, 59% of infants imitated in the reliable condition compared with 30% in the unreliable condition, $\chi^2(1, N = 56) = 4.76$, $p < .05$, and in the sit touch task 50% of infants imitated in the reliable condition compared with 21% in the unreliable condition, $\chi^2(1, N = 56) = 4.98$, $p < .05$.

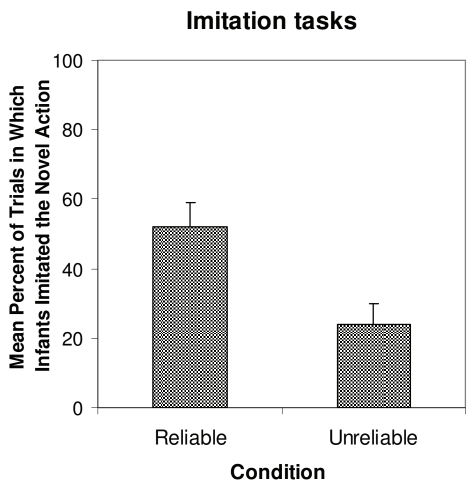

Figure 15. Imitation tasks: Mean percentage of trials in which infants imitated the model's use of the unusual action in each condition.

It is important to note that in both imitation tasks, all infants in both conditions succeeded in turning on the lamp, if not by using the model's unusual action then by using their hands. Thus, infants in both conditions were equally interested in the apparatuses and involved in the tasks, but infants in the reliable condition copied the model's novel action more often than infants in the unreliable condition.

In the preference tasks, in contrast, infants' preference for the same object the model chose did not differ between conditions, Mann Whitney U = 454.5; N = 61, p = .87; see Figure 16. Similar results were found for each task separately (χ^2 tests, both p's > .30). Indeed, even in the reliable condition, infants did not choose the model's preferred object more often than chance (binomial test, p = .41).

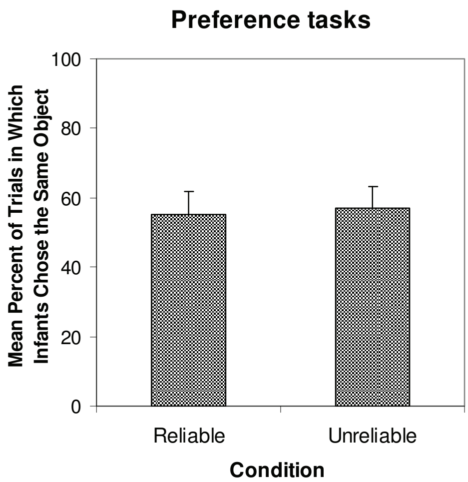

Figure 16. Preference tasks: Mean percentage of trials in which infants chose the same object the model chose in each condition.

The order of presentation of the two types of tasks (imitation tasks first vs. preference tasks first) did not influence results in the preference tasks: infants did not choose the model's preferred object more often in the reliable than the unreliable condition in either order (both p's > .29, Mann-Whitney U test). However, there was an effect of the order of presentation for the imitation tasks. Infants did not selectively imitate the reliable model when the imitation tasks were presented before the preference tasks (in this case they copied 38% of the unusual actions in the reliable condition and 34% in the unreliable condition, U = 111.5; N = 31, p = .71). However, they did selectively imitate the reliable model when the imitation tasks were presented after the preference tasks (in this case they copied 67% of the unusual actions in the reliable condition and 15% in the unreliable condition, $U = 37.0$; $N = 32$, $p < .001$).

Infants watched the familiarization videos closely: the percentages of looking time towards the familiarization videos in the reliable condition for the imitation tasks and for the preference tasks were 96.0% ($SD = 4.6\%$) and 97.4% ($SD = 3.1\%$), respectively. The percentages of looking time towards the familiarization videos in the unreliable condition for the imitation tasks and for the preference tasks were 96.6% ($SD = 3.8\%$) and 97.3% ($SD = 4.4\%$), respectively. A 2 x 2 (Task x Condition) repeated measures ANOVA was performed on the percentage of infants' looking times with type of task (imitation task, preference task) as within-subjects factor and condition (reliable, unreliable) as between-subjects factor. There was no main effect of condition, $F(1, 58) = 08$; $p = .78$, indicating that infants were equally attentive during the familiarization phases in the reliable and the unreliable condition. There was a marginal main effect of type of task, $F(1, 58) = 3.18$; $p = .08$. Infants tended to look longer to the familiarization videos of the preference tasks than to the familiarization videos of the imitation tasks. There was no interaction between condition and type of task, $F(1, 58) = 0.35$; $p = .56$, indicating that in both conditions infants showed a similar looking pattern to the familiarization videos in the imitation and preference tasks.

5.3 Discussion

These findings demonstrate that 14-month-old infants take into account a model's reliability when deciding whether to socially learn from, or not. In each of two imitation tasks, infants in both conditions watched the exact same demonstration of a model using an unusual action to operate a novel apparatus. Infants who had previously watched the model acting competently on a series of other, familiar objects copied this unusual action twice as often as infants who had watched the model acting incompetently. These results suggest that the ability to take into account a model's reliability in imitative learning tasks emerges years earlier than previously reported, already at the beginning stages of infant cultural learning.

One could argue that perhaps infants responded not based on the reliability or unreliability of the model per se but instead simply based on the certainty or uncertainty he showed before acting in the familiarization phase. While this would still be an interesting finding, we think it is unlikely that this alternative explanation can fully account for our results, because Chow et al. (2008) have found that infants of the same age distinguish between reliable and unreliable lookers, and in that study no cues of certainty or uncertainty were given. But perhaps the model's expression of uncertainty was responsible for the pattern of results found in a different, even lower-level way. That is, perhaps something about the model's expression (e.g., the less-positive affect) in that condition caused infants either to like the unreliable model less or to hesitate to do the same things he did for that reason alone. Again we believe this is unlikely, for several reasons. First, in contrast to previous studies with older children (e.g., Akmal & Birch, 2007, Sabbagh & Baldwin, 2001), the model in the current study did not express uncertainty (or certainty) during the test videos at all – in both the reliable and the unreliable condition he acted neutrally, and identically, toward the test apparatuses. Second, we found that infants in the unreliable condition were just as interested in and willing to interact with the test apparatuses as infants in the reliable condition; they just used their hand instead of the unusual means demonstrated to operate them. Finally, the other main finding of this study was that infants did not respond differently across conditions in the preference tasks. This suggests that lower-level cues like affective expressions – which were present in those familiarization videos as well – cannot fully account for the difference found in the imitation tasks.

We believe that infants did not choose the model's preferred object in the preference tasks because they saw the adult's preference as individual and subjective and thus it did not occur to them to copy it. However, as always, negative results are difficult to interpret. For example, it is possible instead that perhaps the slightly different procedure used in the preference tasks' familiarization videos (i.e., having the model choose between two objects) did not capture infants' attention as well as the procedure used in the imitation tasks' familiarization videos (i.e., having him choose which body part to use). Or perhaps infants simply did not see the adult as reliable or unreliable in the preference tasks, for instance because they could not identify the objects the adult chose in the familiarization videos or because they interpreted the adult's behaviour in the unreliable condition as silly or playful instead of unreliable.

Again there are findings that speak against these alternative explanations. First, we found that infants paid close attention to both the preference and the imitation familiarization videos. Second, the finding of an order effect in the imitation tasks counters these lower-level interpretations in two ways: i) the fact that infants performed better in the imitation tasks when they received them after the preference tasks suggests that infants did indeed learn something about the reliability of the model from the preference familiarization videos and ii) infants who were presented with the preference tasks after the imitation tasks still did not choose the object the reliable model preferred more often, despite having already seen evidence of the model's reliability or unreliability in the imitation videos. Finally, and perhaps most convincingly, infants did not choose the same object the model did in *either* condition in the preference tasks, demonstrating that even the preferences of *reliable* models are not likely to be adopted. Still, we cannot fully rule out alternative explanations for the negative results in the preference tasks. Future research is needed to further address differences between cultural learning and preference tasks in infancy.

Along with contributing to the literature on young children's sensitivity to others' reliability, the current study also contributes important information to the literature on infant imitation. We know from many studies that infants are selective imitators (see Carpenter & Call, in press, for a review) but in previous studies of selective imitation what is typically manipulated is the goals or intentions of the model (e.g., Carpenter, Akhtar, & Tomasello, 1998; Meltzoff, 1995) or the physical constraints under which the model is operating (e.g., Gergely, Király, & Bekkering, 2002). In contrast, in the current study, during the test the model successfully achieved his goal in *both* conditions but infants still imitated selectively. In addition, in the unreliable condition the model was operating under a *mental*, not a physical constraint: he lacked knowledge about how to operate the apparatuses. This is thus the first study to demonstrate that 1-year-old infants imitate selectively based on what they think the model knows. Indeed the current study is also the first study to demonstrate this particular type of knowledge/ignorance understanding in any domain. Previous studies of this understanding have all focused on infants' understanding of what the adult has or has not seen in the past (e.g., Liszkowski, Carpenter, & Tomasello, in press; Onishi & Baillargeon, 2005) or what the adult is familiar with from past experience (e.g., Tomasello & Haberl, 2003). In the current study, in contrast, infants had to understand whether or not the adult was knowledgeable about how things work.

To sum up, we believe that infants' selective copying of the reliable model in the imitation tasks reflects infants' readiness to participate in human cultural and conventional learning. That is, although infants probably noticed the model's reliability in both types of tasks, they used this information to guide their own responses only in the imitation tasks. They did not do this in the preference tasks because, almost by definition, a person's preferences are individual and not generalizable. Thus, Experiment 4 suggests that 14-month-olds not only distinguish between reliable and unreliable persons, but also distinguish between individual preferences and potentially conventional and transferable activities of other members of their culture. Infants, already by 14 months of age, are surprisingly discriminating imitators.

6 General Discussion

From an early age, infants not only interact with their parents and (if they have them) their older siblings at home, but possibly also at day nursery, their peers, as well as older and younger children. Since infants learn on average one action per day from others via imitation (Barr & Hayne, 2003), it is important to investigate under what conditions infants imitate conspecifics of various ages. In this dissertation these conspecifics were divided into three different age groups: peers, older children, and adults. As outlined above (cf. chapter 1.2.3.2), the benefit of imitating a member of a certain age might be selectively connected to this particular age group. There are several studies in which infants' attention and preferences were investigated when confronted with individuals of different age groups (Brooks & Lewis, 1976; McCall & Kennedy, 1980; Sanefuji et al., 2005, 2006b). However, little is known about peer imitation in infancy, let alone about the relationship between peer imitation and imitation of older models. Hanna and Meltzoff (1993) were the first to show that 14-month-olds are able to imitate peers. Ryalls et al (2000) extended this finding by showing that 14- to 18-month-olds perform better in imitating action sequences when they are given a demonstration by a 3-year-old model as compared to an adult model. Stimulated by these findings, the focus of this dissertation was the significance on infant imitation of a model's age. Firstly, in a series of successive experiments, I developed a setup for investigating via video presentation the imitation of a novel action. Secondly, I explored how infants copied novel and familiar behaviour performed by differently aged models and if infants were more likely to re-enact failed attempts of familiar actions from a certain age category of model. Under the assumption that adult models are perceived by infants as being more reliable than peer or child models, I finally investigated how a model's reliability influenced imitation of novel actions and individual preferences.

Hanna and Meltzoff (1993) and Ryalls et al. (2000) used live models in their studies. However, in my experience, this procedure bears the risk that the presentation of the target action during demonstration may differ widely due to peer models being unable to repeatedly perform an identical action. Perhaps even more problematic, is the fact that there may be fundamental differences in peer-infant and adult-infant interaction that are hard to control for, such as infant directed speech, eye contact, addressing the infants by their names, and arbitrary actions before and after the target behaviour. Thus, we preferred to use televised models in order to investigate the role of a model's age in infant imitation.

6.1 Summaries of the Experiments

In Experiment 1, we tested whether infants were able to detect differences in the rationality of a novel action when the models were televised. We showed that 12-month-olds, but not 9-month-olds, were able to imitate the use of the head in order to turn on a lamp if they had observed a televised model doing so beforehand. Moreover, 12-month-olds selectively imitated this action more frequently if an explicit and non-voluntary situational constraint hindered the model from using the more straightforward hand action: they did so less often in a condition in which the hands of the model were free. However, we could not replicate the original finding by Gergely et al. (2002), who reported that infants did not differentiate between the hands-free condition and the hands-occupied condition. In the latter condition the constraint was an implicit and voluntary one because the model's hands were occupied with holding a blanket. Besides demonstrating the emerging imitative abilities between 9 and 12 months of age, this experiment has also gone some way towards supporting the use of televised models, particularly in order to investigate the impact of subtle model variables such as a model's age.

In Experiment 2, we investigated the influence of the model's age on infants' tendency to imitate depending on whether a novel behaviour (Experiment 2a: head touch) or a familiar behaviour (Experiment 2b: body movements) were presented. The results obtained in Experiment 2a showed that the likelihood of imitating a novel action increased as the age of the model increased. In general, imitation of a novel action could be interpreted in terms of the cognitive function of imitation, namely, that infants were motivated to learn a novel skill. In this particular experiment, however, infants were not only eager to learn a novel action but they selectively imitated the adult model more often than either the older child or the peer model. Therefore, infants might have perceived the adult as a reliable teacher when he demonstrated the head touch and they might have assumed that his novel behaviour provided some opaque advantage. In contrast, the head touch demonstrated by the older child and the peer might have been interpreted solely as an ineffective way to illuminate the lamp. In contrast to Experiment 2a, Experiment 2b revealed that infants imitated a peer model more often when they were presented with familiar body movements. In general, peer imitation is interpreted as a non-verbal method of communication (e.g., Eckerman et al., 1989). Thus, the results of Experiment 2b suggest that infants might have imitated peers for social reasons. They might have engaged in less imitation of older age groups because adults and older children are also able to use verbal methods of interacting with infants. There is evidence that infants have a preference for peers indicated by looking time and social responses such as smiling (Bahrick et al., 1998; Bigelow et al., 1990; Greenberg, et al., 1973; Lewis & Brooks, 1975; Sanefuji et al., 2005). It is likely that they pursued this preference in the relatively social context of Experiment 2b rather than in the relatively cognitive context of Experiment 2a. All in all, the findings of Experiment 2 led to the conclusion that infants imitated for social reasons when observing familiar behaviour and for cognitive reasons when observing novel behaviour. However, the impact of Experiment 2 is limited by the differences in the behaviour demonstrated. In Experiment 2a, an object-directed action was presented and imitation was coded after the demonstration of the target act. By contrast, in Experiment 2b, body movements were shown and imitation was coded during the demonstration of the target acts.

The motivation for Experiment 3 was twofold. First, we wanted to address the question of whether the type of behaviour and the time at which imitation was coded influenced the findings of Experiment 2b. Second, we wanted to explore whether 14-month-olds, when faced with re-enacting unsuccessful object-directed actions, benefited more from having peers or older children conduct the demonstration. Therefore, 14-month-old infants were tested with a modified version of Meltzoff's (1995) study including full demonstrations and failed attempts at familiar object-directed actions. The results were mixed. Regarding our first aim, the main finding of Experiment 2b was replicated: 14-month-olds were also more likely to imitate peers as compared to older children or adults when observing complete familiar object-directed actions. On the contrary, with respect to our second research question, 14-month-olds did not re-enact the failed attempts of either model age group. The first finding did not only replicate the results of Experiment 2b, it also showed that infants are more likely to imitate peers independent of the specific behaviour. The second finding, however, showed that this effect may be limited to complete sequences of behaviour and does not extend to failed attempts. Alternately, the second finding might be due to the limited abilities of 14-month-olds to re-enact failed attempts at all.

Finally, in Experiment 4 we wanted to shed more light on the findings of Experiment 2a, that is, why 14-month-olds were most likely to imitate the adult model when they observed differently aged models performing the novel head touch. We speculated that infants imitated this action in order acquire a novel skill. Because not all models were equally knowledgeable, infants selectively imitated the most reliable model, namely, the adult. Therefore, in Experiment 4, 14-month-old infants observed an adult model acting either reliably or unreliably on familiar objects, and subsequently, and subsequently witnessed the model performing the novel head touch or the novel sit touch. Furthermore, we wanted to explore whether infants selectively copied individual preference choices more or less frequently from reliable models.Results showed that that this was not the case: infants chose independently of the reliable or unreliable model's choice.

6.2 A Closer Look at the Two Functions of Imitation

As outlined in the introduction of Experiment 2, infants may have more than one motivation for copying another person's behaviour. Uzgiris (1981) initially suggested that imitation has two functions: one cognitive and one social. The cognitive function serves to acquire novel skills. Nielsen and Slaughter (2007) argued that this function prevails in studies of infant imitation. For example, Piaget (1962) regarded imitation as a marker for infants' cognitive development. The notion of imitation as a tool for learning novel skills is also mirrored in definitions of imitation that emphasize that an action has to be novel in order to investigate imitation in infancy (e.g., Byrne & Russon, 1998). By contrast, the social function of imitation is regarded as a non-verbal way of communication via the sharing of experiences with others (Nielsen & Slaughter, 2007; Uzgiris, 1981). Even adults who are able to affiliate verbally employ non-verbal (and unconscious) mimicry when interacting with others (Lakin & Chartrand, 2003). Considering the ongoing debate about whether rich interpretations of infants' behaviour are appropriate (Munakata, Bauer, Stackhouse, Landgraf, & Huddleston, 2002; Onishi & Baillargeon, 2005; Perner & Ruffman, 2005), it should be noted that infants do not have to be aware of the actual function of their imitative behaviour. Even adults are not aware of mimicking each other in conversation (e.g., see Chartrand & Bargh, 1999), although this behaviour is possibly of evolutionary significance for everyday interaction (Lakin et al., 2003).

Uzgiris (1981) and Nielsen and Slaughter (2007) suggested that an identical behaviour can be imitated both for cognitive and social purposes. These two functions can even be present at the same time. According to Uzgiris, the cognitive function of imitation decreases with increasing age, whereas the opposite is true for the social function of imitation. However, no further variables are specified in order to predict the type of imitation. Almost by definition, the cognitive function of imitation can only be applied to another person's novel behaviour, because infants can only learn behaviour that is not already part of their action repertoire. On the contrary, the social function of imitation may be more easily applied to another person's familiar behaviour, because infants can focus on the communicative aspect of imitation. If these assumptions are valid, one can specify conditions under which infants rely on the cognitive function and on the social function of imitation. In Experiment 2a, we demonstrated that infants were more likely to imitate a novel behaviour witnessed in an adult model. We assumed that an adult model is perceived as the most reliable source of information. In fact, we could show in Experiment 4 that infants imitated a reliable adult more often than an unreliable adult when presented with novel actions. Thus, one can conclude that infants seek out reliable models when imitating novel actions: they evaluate a model's reliability based on his or her age or from the model's past accuracy with familiar objects. By contrast, in Experiment 2b we showed that infants were more likely to imitate familiar body movements from peers as compared to older children and adults. Irrespective of the type of behaviour and time of coding, we could show in Experiment 3 that infants were also more likely to imitate complete familiar object-directed actions from peers as compared to older models. We understood that infants perceived peer models as being the most similar to them, and due to the fact that both infant and peer model are both preverbal, we further assumed that infants imitated peer models for communicative reasons, namely, to interact non-verbally with the model.

This argument is an extension of Uzgiris's (1981) theory which states that infants are able to detect similarity between themselves and others and that infants react differently to novel and familiar behaviour. There is empirical evidence for both assumptions that I will now expand upon.

Rochat and Striano (2000) assumed that young infants have a rudimentary and implicit form of self representation. They develop this sense of the self via the active process of intermodal perception and exploration. In a number of studies it was shown that infants between 3 and 6 months of age are able to differentiate between the view of their own legs and the view of other infants' legs (Bahrick & Watson, 1985), a mirrored view of their own legs (Rochat & Morgan, 1995), and a delayed view of their own legs (Zmyj, Hauf, & Striano, 2008). Furthermore, infants from 3 months onwards are able to discriminate between their own face and a peer's face (Bahrick, Moss, & Fadil, 1996; Legerstee, Anderson, & Schaffer, 1998). Based on the ability to represent the self, Meltzoff (2005) also speculated about infants' ability to make comparisons between self and others. He assumed that the ability to imitate and the ability to detect regular relationships between own behaviour and underlying mental states are prerequisites of perceiving others as "like me".

There is also empirical evidence for infants' ability to evaluate the familiarity and novelty of behaviour. First, Woodward (1999) showed that infants are able to understand familiar actions but not novel actions as goal-directed (for an alternative explanation, see (Jovanovic et al., 2007; Király et al., 2003). Second, the jury is still out as to whether there is a connection between infants' ability to understand another agent's action and the ability to perform the very same action. However, some researchers suggest that infants' action understanding is modulated by the infants' capacity to perform the corresponding action on their own (Daum, Prinz, & Aschersleben, 2008c; Sommerville et al., 2005). Based on these findings, one might speculate that an infant's evaluation of the familiarity of behaviour is altered by the infant's own action repertoire.

To summarise, the familiarity of a behaviour may influence an infant's likelihood of using imitation for cognitive or for social reasons. Whilst I speculated that in the context of familiar behaviour the social function of imitation is wider ranging than the cognitive function of imitation, in the context of novel behaviour the opposite is true.

6.3 Human Pedagogy

The notion of imitation as a method of learning novel behaviour raises the question: how is imitation embedded in human pedagogy? Gould (1979) speculated on an association between Lamarck's (1809/1990) theory about the evolution of species and cultural evolution in humans. For the evolution of species, Lamarck argued for the inheritance of acquired body characteristics. That is, what an individual's body has experienced in its lifetime is inherited by that individual's offspring. This theory was dismissed in favour of Darwin's theory of mutation and natural selection (Darwin, 1859/1981). However, Gould (1979) noted that cultural evolution contains by definition a Lamarckian character. That is, humans transmit cultural knowledge predominantly vertically across generations and not horizontally within one generation (Guglielmino, Viganotti, Hewlett, & Cavalli-Sforza, 1995). Although many species may depend on both genetic and cultural inheritance (Durham, 1991), human beings depend on cultural inheritance more than any other species (Tomasello, 1999). The strong inclination to adopt the behaviour of others is illustrated by studies showing that children reproduce an adult's inefficient actions on novel objects (Call et al., 2005; Carpenter, Call, & Tomasello, 2002) even in situations where chimpanzees correctly ignore the unnecessary part of the action (Horner & Whiten, 2005; Want & Harris, 2002). For example, Horner and Whiten presented both children and chimpanzees with a transparent box and an opaque box containing a reward. In order to obtain a reward, the demonstrator performed an irrelevant action (i.e., he inserted a tool in a hole at the top of the box, which was separated from the reward by a barrier) followed by a relevant action (e.g., he inserted the tool in the hole at the front of the box and pulled out the reward). In the opaque condition, both, children and chimpanzees copied the irrelevant action in the hole at the top of the box, presumably, because they could not know that this action was irrelevant. However, in the transparent condition, children reproduced the irrelevant step, whereas chimpanzees did not. Lyons, Young, and Keil (2007) put forward the idea that what they call 'overimitation' is due to the fact that children encode all of the demonstrator's actions as causally meaningful, implicitly revising their causal understanding of the object. At first glance, one may assume that the children are 'blind imitators'. However, children also use their understanding of the person's overall goal to guide their imitation (Bekkering, Wohlschläger, & Gattis, 2000; Williamson & Markman, 2006) and children's prior hands-on experience influences the likelihood of adopting a novel strategy to operate an apparatus (Williamson, Meltzoff, & Markman, 2008). Accordingly, when children do not understand the overall reason for a model's behaviour or if the model repeatedly performs the same inefficient action, they will be more likely to imitate every observable means. By copying precisely in these situations, children may have a good chance of reproducing the model's action correctly. In contrast, when the goal of an action and the mechanism of an apparatus are clear, children will be more likely to ignore the model's action and use their own method to complete the action. This line of research always used adults as models who are presumably perceived as knowledgeable. However, in several studies it was shown that preschoolers take into account a model's reliability when deciding whether or not to socially learn from this model (Jaswal & Malone, 2007; Jaswal & Neely, 2006; Koenig & Harris, 2005a, 2005b; Pasquini et al., 2007).

The notion of the import of a model's reliability on social learning in childhood begs the question: how is learning by imitation realized in infants? Gergely et al. (2002) provided evidence that even infants are more likely to copy means in cognitively opaque situations compared to situations where the reason for an action is clear. Furthermore, it is assumed that both adults and infants posses complementary cognitive mechanisms for teaching and learning (Csibra & Gergely, 2006; Gergely, 2008; Gergely & Csibra, 2005). The adult is naturally prepared to mark with ostensive cues that knowledge that can be generalised. In turn, the infant is naturally prepared to interpret correctly these manifestations of generalizable knowledge. The present dissertation indicates that infants, analogous to children, do not blindly copy every action. In Experiment 2a, we showed that infants are highly selective when reproducing another individual's behaviour. That is, when infants perceive a novel action they are more likely to learn from an adult model as compared to a child model or a peer model. Since the stability of cultural knowledge deeply depends on transgenerational transmission, infants and children may be inclined to learn from adults that are more knowledgeable than younger conspecifics. In the head touch task, infants imitated the adult model although they were able to use their hands. This result provides the first evidence that the tendency to reproduce all of the model's behaviour in cognitively opaque situations (Horner & Whiten, 2005; Lyons et al., 2007) is limited to adult models. In Experiment 4, we expanded upon this finding by showing that infants are more likely to imitate a reliable model as compared to an unreliable model when they encounter the novel head touch task and sit touch task.

I think that the sensitivity to a model's characteristics, such as age and reliability, when learning novel behaviour is closely related to infants' and children's tendency to overimitate inefficient actions. Given their willingness to adopt arbitrary actions even in situations where they perceive them as irrelevant or inefficient, one can not overestimate their sensitivity to a model's reliability. A model's age and a model's past accuracy are good predictors of the benefit of a novel behaviour, even if the behaviour seems inefficient at first glance. One might argue that throughout our evolutionary history, teaching usually occurred within families thus causing children to be entirely dependent upon their parents for the transfer of cultural knowledge. However, a cross-cultural comparison has indicated that modern childcare centres are not as novel as was previously thought (Hrdy, 2007). Hrdy put forth the cooperative breeding hypothesis, namely, that allomaternal assistance was essential for child survival during the Pleistocene period. The Pleistocene era ran from about 1.8 million years ago to 10000 years ago and represents the period when hominids evolved. The cooperative breeding system, where the birthmother could rely on other women to bring up her child, allowed her to give birth to more children than she could nurse on her own. A direct result of such a social context is that infants and children benefit from the care and provision of a number of supervisory individuals. This developmental context, where infants and children are required to read the intentions of others and learn from allomothers, has obvious implications for the evolution of mechanisms that allow for the evaluation of a conspecific's reliability. Since the Pleistocene child is thought to be surrounded by children of various ages and several adult carers, they should be inclined to preferentially learn from the adult carers because adults are usually more reliable than children. Of course, in some domains, older children might be more reliable models than adults; however in general, adults know better than children what is vital and adaptive and what is not. Moreover, children should preferentially learn from reliable rather than from unreliable carers, because those children are then more likely to survive and prosper.

6.4 Infant Non-Verbal Communication

The notion of imitation as a method of non-verbal communication poses the question: what role does non-verbal communication play in preverbal infants? Initially, Acredolo and Goodwyn (1988; 1985) reported that symbolic gestures develop in tandem with children's vocabulary. Symbolic gestures are defined as simple body movements that are used to represent objects and events (e.g., sniffing for "flower", index fingers tapping together for "more"). Furthermore, they are perceived as communicative and carry the meaning in their own form beyond directing the attention towards the referent. The authors concluded conservatively that symbolic gestures and early words are both representatives of common underlying mechanisms, namely, the recognition that things have names. In recent research it has been suggested that early gestures paved the way for later language development by facilitating word learning (Goldin-Meadow, Goodrich, Sauer, & Iverson, 2007; Iverson & Goldin-Meadow, 2005; Rowe, Ozcaliskan, & Goldin-Meadow, 2008). Moreover, in some studies it has been reported that expressive language appeared first in gesture before its emergence in vocal language (Goodwyn & Acredolo, 1993; Goodwyn, Acredolo, & Brown, 2000; Holmes & Holmes, 1980). Furthermore, it has been suggested that the intense use of symbolic gesturing in preverbal infants improves later vocal language acquisition (Goodwyn & Acredolo, 1998; Goodwyn et al., 2000). Based on this array of studies, Goodwyn and Acredolo invented the Baby Signs ® program. In this program parents are taught to use signs in order to communicate with their child before the child can use vocal language. Baby sign language has enjoyed enormous popularity in the past decade. For example, London researchers investigating this phenomenon had difficulties finding families for a control group that were *not* enrolled in baby sign language classes (E. Kirk, personal communication, July 23, 2008). However, there is also some scepticism about the advantages of sign language over vocal language, due to early gestures being potentially direct imitations of the parent model or over-interpretations by parents of excitatory gestures (e.g. open-close fist interpreted as signs for milk or want, Morgan, 2008, Morgan, Herman, Barriere, & Woll, 2008).

In either case, it is well accepted that infants use gestures in order to socially interact with other individuals, for example when provide information by pointing (Liszkowski, Carpenter, Striano, & Tomasello, 2006; Liszkowski, Carpenter, & Tomasello, 2007) or when they copy another persons' behaviour (Eckerman et al., 1989; Eckerman & Whatley, 1977). In the latter case we showed that infants reproduce familiar body movements as well as complete familiar object-directed actions predominantly from peers as compared to older children or adults. In the context of familiar behaviour, infants might have been more motivated to affiliate with peers because peers are the most similar to them as opposed to older children or adults. This strategy makes sense as both the peer model and the infant participant are preverbal and gestures provide a non-verbal way of interacting with each other. An adult's tendency to be more helpful when someone mimics them could be related to a corresponding behaviour in infants. Uebel, Carpenter, and Tomasello (2008) showed that toddlers who were mimicked by an adult experimenter behaved more pro-socially towards her than infants who were not mimicked.

6.5 Implications for Future Research

In this dissertation, I was able to answer many open questions. But as a consequence, many new questions have also emerged. Almost by definition, these open questions do not only pave the way for further research but they also show the limitations of the present work. In the following, I will first discuss the use of different target behaviours in the experiments. Second, I will discuss some open questions that arise from each experiment.

Across the four experiments, we used imitation tasks involving different forms of target behaviours. In Experiment 1, Experiment 2a and the imitation tasks of Experiment 4 the target behaviours were concerned with the achievement of a result (i.e., illuminating a lamp) using a specific means (e.g., bending at the waist and pushing the lamp with the head). In many studies and accounts of imitation it is assumed that infants indeed chose a specific body part to operate the lamp and that no lower mechanisms are involved (e.g., Gergely et al. 2002; Meltzoff, 1988; Tomasello et al.

2005). In Experiment 3, we used the target behaviours that Meltzoff (1995) used in his study (e.g., putting beads into a cup). There is some debate as to which mechanisms are involved in these kinds of tasks. Some researchers argue that emulation and stimulus enhancement are involved (Huang & Charman, 2005; Huang et al., 2002). Other researchers, however, have shown in a task from Meltzoff's (1995) study (i.e., pulling a dumbbell apart, Call et al. 2005) that 2-year-olds are able to focus on the specific means of reaching a goal. The target behaviour in Experiment 2b only consisted of a body movement (e.g., waving) which was labelled as mimicry according to Tomasello's (1999) definition of social learning.

Tomasello (1999) stressed the differentiation between imitation, emulation and mimicry because he suggested that this distinction sheds more light on cultural evolution in humans and the lack of culture in apes. He assumed that many species are able to mimic, that apes are able to emulate, however, only humans are able to imitate. Since culture depends deeply on imitation Tomasello's explanation accounted for the fact that only humans have culture. Other researchers, focusing more on human ontogeny than on human phylogeny, do not draw a strict line between these forms of social learning. For example, Jones (2007) viewed mimicry as one form of imitation. She further assumed that imitation in general, and mimicry in particular, is an amalgamation of different ways of using and combining different kinds of knowledge. Thus, one can suggest that every imitation task is more or less qualitatively different from another imitation task, even if the same overall structure is used (e.g., using specific means to achieve a result). In this dissertation, I was mainly interested in which variables influence an infant's reproduction of another person's behaviour. I partially controlled for the different mechanisms that were involved in infants' imitative behaviour; for example, different forms of familiar behaviour were used to demonstrate the effect of differently aged models and the familiarity of behaviour (Experiment 2b: body movements; Experiment 3: object-directed actions). Furthermore, two different tasks involving novel behaviours were used in Experiment 4 (head touch task; sit touch task) to demonstrate the effect of a model's reliability. I do not believe that the main findings of this dissertation were fundamentally influenced by different types of social learning, and I have put a great deal of effort into finding evidence to show that this was not the case. However, I cannot completely rule out this possibility and I hope that future research methods will find a way of investigating this issue in greater detail. Beyond this concern, each experiment also raises its own open questions that I would like to discuss below.

In the first experiment, we extended the rational imitation paradigm used by Gergely and colleagues (2002). We found compelling evidence that 12-month-olds, but not 9-month-olds, imitated rationally when comparing the conditions where the model's hands were free and the condition where the hands were explicitly and non-voluntarily restrained. However, the phenomenon of rational imitation still attracts scepticism. Paulus et al (2008), for example, argued that motor resonance could explain the pattern of results in the head touch task. As noted in the introduction, there is strong evidence for motor resonance playing an important role in imitation (Brass, Bekkering, Wohlschläger, & Prinz, 2000; Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995; Wilson & Knoblich, 2005). For adults, Brass et al. (2007) found no evidence that the mirror neuron system, which is conceived as a base for motor resonance, was involved in tasks that were analogous to Gergely et al.'s (2002) version of the head touch task. However, it is unclear as to what extent motor resonance is involved in the head touch task for infants. Paulus et al. (2008) suggested that in the original study by Gergely et al. (2002) infants only imitated an action if they were able to match a model's action in their own action repertoire. In the hands-free condition the posture of the model and of the infant were almost identical (i.e., hands resting on the table); hence, infants imitated the head touch. In contrast, the posture of the model and of the infant differed in the hands-occupied condition (i.e., the model's hands held a blanket and the infants' hands rested on the table) which led to less motor resonance and therefore less imitation. For the hands-restrained condition in Experiment 1 of this dissertation, Paulus et al. (2008) put forward the idea that infants might have re-enacted a failed hand touch because the model clapped on the table three times in order to illustrate the restrained status of the hands. Paulus et al. (2008) reported two variations of the hands-free condition which were regarded as supporting their account of motor resonance. In the hands-up condition, the hands were held in the air while the model performed the head touch. In the button condition, the hands were put under a blanket which was wrapped around the model's shoulders; however a large button and not the model's hands kept the blanket in this position while the model performed the head touch. In both conditions, infants were less likely to perform the head touch than in the original hands-free condition. Although these results seem to challenge the rational imitation account, the procedure used has a number of weaknesses: namely, infants might have perceived the hands as occupied in both conditions. In the hands-up condition, infants might have perceived the posture itself as an occupation. Likewise, in the button condition, infants might still have perceived the hands as being occupied holding the blanket. For further clarification, one could design a condition where the hands are not visible (analogous to the hands-occupied condition) but are free (analogous to the hands-free condition). For example, a small screen could block the infants' visual access to the model's hands. This condition could be juxtaposed to a condition where the screen does not block the infants' visual access to the model's hands. If motor resonance can account for the pattern of results in the head touch task, one would expect less head touches in the condition with no visual access to the hands as compared to condition that did allow visual access to the hands. In contrast, according to the logic of rational imitation one would predict that in both conditions the hands would be perceived as free. Thus, most infants should imitate the head touch in both conditions.

One should be aware that future studies may show that both motor resonance and the principle of rational action might be at work in the head touch task because both mechanisms are on different theoretical levels. The motor resonance account provides a theoretical framework for explaining the mechanism of imitation. The principle of rational action however provides a theoretical base for explaining how situational circumstances modulate the capacity to imitate. Liepelt, von Cramon, and Brass (2008) illustrated this differentiation in their study. They showed that the mirror neuron circuit is involved in representing basic intentional action (i.e., a full-blown lifting movement of the index finger). Interestingly, they reported also that for non-stereotypical actions (i.e., a tiny lifting movement of the index finger), brain areas used for reasoning about mental states are activated.

In Experiment 2 and Experiment 3, we were able to show that 14-month-olds selectively imitate differently aged models based on the familiarity of the behaviour. We found that infants imitated predominantly the adult model if a novel object-directed action was demonstrated (Experiment 2a). We found that the opposite was true for familiar body movements (Experiment 2b) and familiar object-directed action

(Experiment 3). It goes without saying that laboratory experiments are of limited ecological validity. Therefore, investigating live interactions in infant-adult and infant-peer dyads could shed more light on the significance of this effect in more lifelike interaction. However, it might be challenging to find an experimental setting that provides as comparably controlled an environment as the televised demonstration behaviour.

We could not find a 'peer advantage' when testing re-enactment of failed attempts. Because it is not certain that 14-month-olds are capable of re-enacting failed attempts from television, we discussed two possible explanations. First, infants older than 14 months of age might have been more likely to re-enact failed attempts from peers than from older models, or second, infants older than 14 months of age might not take into account a model's age when re-enacting failed attempts. In order to explore the effect of a model's age it would be more informative to test older infants that are able to re-enact failed attempts. Investigating the re-enactment of the failed attempts of differently aged models was a first step towards exploring the impact of differently aged models on infants' social cognition. Other areas of social cognition such as the early development of a theory of mind (Buttelmann, Carpenter, & Tomasello, 2008; Onishi & Baillargeon, 2005) might be modulated by an agent's age as well. Buttelmann et al. (2008), for example, reported that about one third of infants across three different age groups (16-, 18-, and 30-month-olds) failed to infer the false belief of the adult experimenter. We argued that infants perceive adults as competent agents and others even suggest that infants perceive adults as omniscient (Csibra & Gergely, 2006). In false belief tasks, infants might therefore encounter two competing tendencies. On the one hand, they assume that the adult has a false belief, and on the other hand, they perceive him as a competent and omniscient agent. Some toddlers in Buttelmann et al.'s (2008) study might have dismissed information about the adult's current false belief in favour of their assumption concerning the competent and omniscient adult. If one used same-age agents that hold a false belief, one could decrease this conflict.

In Experiment 4, we provided the first evidence that 14-month-olds take into account the reliability of a model when imitating novel actions. That is, infants are more likely to adopt novel actions from a reliable model as compared to an unreliable model. I have speculated about the evolutionary significance of this selectivity for our ancestor's cooperative breeding models (Hrdy, 2007) where infants were confronted with conspecifics of different ages and of various levels of competence. There might have been other evolutionarily significant contexts where it was adaptive to selectively adopt behaviour of a certain subgroup of conspecifics; for example, the in-group bias is defined as "relative positivity towards in-groups vis-à-vis out-groups" (Brewer, 2007, p. 730). The in-group bias might have played an important role in human evolution because some evolved characteristics such as tool-making create deep dependence on collective knowledge and cooperative information sharing (Brewer, 2007; Caporael & Brewer, 1995). Therefore, a motivation for affiliation might have evolved at the individual level. On the contrary, a unidirectional motivation for affiliation would not have been adaptive without an antagonistic motivation for differentiation and exclusion. Kinzler, Dupoux, & Spelke (2007) reported that infants differentiate between in-group and out-group members based on speech, and Bar-Haim, Ziv, Lamy, & Hodes (2006; see also Brewer, 2007) demonstrated a similar effect elicited by a conspecific's race. Given the hypothesised evolutionary significance of in-group bias and the presence of in-group bias in infants' visual preferences, it should be interesting to see whether infants also are more likely to socially learn from in-group members as compared to out-group members.

7 Conclusion

This dissertation investigated the role of a model's age and reliability and the role of situational constraints and completeness of actions in infant imitation. In conclusion, I found that infants are remarkably flexible imitators. I hypothesized that at least two distinct motivations for imitation might play a crucial role in these experiments: namely, besides the motivation to learn, infants also imitate for social reasons. In my opinion, the underlying motivation for imitation is a highly informative area for understanding human ontogeny. In particular, understanding imitation as a non-verbal form of communication and affiliation may shed more light on the social side of social-cognitive development in infancy.

References

Abramovitch, R., & Grusec, J. E. (1978). Peer imitation in a natural setting. *Child Development, 49*, 60-65.

Abravanel, E., & DeYong, N. G. (1997). Exploring the roles of peer and adult video models for infant imitation. *Journal of Genetic Psychology, 158*, 133-150.

Acredolo, L., & Goodwyn, S. (1988). Symbolic gesturing in normal infants. *Child Development, 59*, 450-466.

Acredolo, L. P., & Goodwyn, S. W. (1985). Symbolic gesturing in language development: A case study. *Human Development, 28*, 40-49.

Ainsworth, M. D. S., & Wittig, B. A. (1969). Attachment and exploratory behaviour of one-year-olds in a strange situation. In B. A. Foss (Ed.), *Determinants of infant behaviour* (Vol. 4, pp. 111-136). London: Methuen.

Anderson, D. R., & Pempek, T. A. (2005). Television and very young children. *American Behavioral Scientist, 48*, 505-522.

Anisfeld, M. (1979). Interpreting "imitative" responses in early infancy. *Science, 205*, 214-215.

Anisfeld, M. (1996). Only tongue protrusion modeling is matched by neonates. *Developmental Review, 16*, 149-161.

Anisfeld, M. (2005). No compelling evidence to dispute Piaget's timetable of the development of representational imitation in infancy. In S. Hurley & N. Chater (Eds.), *Perspectives on imitation: From cognitive neuroscience to social science* (Vol. 2, pp. 107–131). Cambridge, MA: MIT Press.

Asendorpf, J. B., & Baudonniere, P.-M. (1993). Self-awareness and other-awareness: Mirror self-recognition and synchronic imitation among unfamiliar peers. *Developmental Psychology, 29*, 88-95.

Bahrick, L. E., Moss, L., & Fadil, C. (1996). Development of visual self-recognition in infancy. *Ecological Psychology, 8*, 189-208.

Bahrick, L. E., Netto, D., & Hernandez-Reif, M. (1998). Intermodal perception of adult and child faces and voices by infants. *Child Development, 69*, 1263-1275.

Bahrick, L. E., & Watson, J. S. (1985). Detection of intermodal proprioceptive-visual contingency as a potential basis of self-perception in infancy. *Developmental Psychology, 21*, 963-973.

Bandura, A. (1965). Influence of models' reinforcement contingencies on the acquisition of imitative reponses. *Journal of Personality and Social Psychology, 1*, 589-595.

Bandura, A. (1977). *Social learning theory*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A., & Kupers, C. J. (1964). Transmission of patterns of self-reinforcement through modeling. *The Journal of Abnormal and Social Psychology, 69*, 1-9.

Bandura, A., Ross, D., & Ross, S. A. (1961). Transmission of aggression through imitation of aggressive models. *Journal of Abnormal and Social Psychology, 63*, 575-582.

Bandura, A., Ross, D., & Ross, S. A. (1963). A comparative test of the status envy, social power, and secondary reinforcement theories of identificatory learning. *Journal of Abnormal and Social Psychology, 67*, 527-534.

Bar-Haim, Y., Ziv, T., Lamy, D., & Hodes, R. M. (2006). Nature and nurture in own-race face processing. *Psychological Science, 17*, 159-163.

Barr, R., & Hayne, H. (1999). Developmental changes in imitation from television during infancy. *Child Development, 70*, 1067-1081.

Barr, R., & Hayne, H. (2003). It`s not what you know, it`s who you know: Older siblings facilitate imitation during infancy. *International Journal of Early Years Education, 11*, 7-21.

Barr, R., Muentener, P., & Garcia, A. (2007). Age-related changes in deferred imitation from television by 6- to 18-month-olds. *Developmental Science, 10*, 910-921.

Barr, R., Muentener, P., Garcia, A., Fujimoto, M., & Chavez, V. (2007). The effect of repetition on imitation from television during infancy. *Developmental Psychobiology, 49*, 196-207.

Becker, S., & Glidden, L. M. (1979). Imitation in EMR boys: Model competency and age. *American Journal of Mental Deficiency, 83*, 360-366.

Behne, T., Carpenter, M., Call, J., & Tomasello, M. (2005). Unwilling versus unable: Infants' understanding of intentional action. *Development Psychology, 41*, 328-337.

Bekkering, H., Wohlschläger, A., & Gattis, M. (2000). Imitation of gestures in children is goal-directed. *Quarterly Journal of Experimental Psychology, 53*, 153-164.

Bellagamba, F., & Tomasello, M. (1999). Re-enacting intended acts: Comparing 12- and 18-month-olds. *Infant Behavior & Development, 22*, 277-282.

Bigelow, A., MecLean, J., Wood, C., & Smith, J. (1990). Infants responses to child and adult strangers: An investigation of height and facial configuration variables. *Infant Behavior & Development, 13*, 21-32.

Birch, S. A. J., Vauthier, S. A., & Bloom, P. (2008). Three- and four-year-olds spontaneously use others' past performance to guide their learning. *Cognition, 107*, 1018-1034.

Bischof, N. (1985). *Das Rätsel Ödipus [The Oedipus riddle]*. Munich: Piper.

Bischof, N. (2008). *Psychologie [Psychology]*. Stuttgart: Kohlhammer.

Brass, M., Bekkering, H., Wohlschläger, A., & Prinz, W. (2000). Compatibility between observed and executed finger movements: Comparing symbolic, spatial, and imitative cues. *Brain and Cognition, 44*, 124-143.

Brass, M., Schmitt, R. M., Spengler, S., & Gergely, G. (2007). Investigating action understanding: Inferential processes versus action simulation. *Current Biology, 17*, 2117-2121.

Brewer, M. B. (2007). The importance of being we: Human nature and intergroup relations. *American Psychologist, 62*, 728-738.

Brody, G. H., & Stoneman, Z. (1981). Selective imitation of same-age, older, and younger peer models. *Child Development, 52*, 717-720.

Brody, G. H., & Stoneman, Z. (1985). Peer imitation: An examination of status and competence hypotheses. *Journal of Genetic Psychology, 146*, 161-170.

Brooks, J., & Lewis, M. (1976). Infants' responses to strangers: Midget, adult, and child. *Child Development, 47*, 323-332.

Buttelmann, D., Carpenter, M., Call, J., & Tomasello, M. (2008). Rational tool use and tool choice in human infants and great apes. *Child Development, 79*, 609-626.

Buttelmann, D., Carpenter, M., & Tomasello, M. (2008). *Sixteen-month-olds show false belief understanding in an active helping paradigm*, Manuscript submitted for publication.

Byrne, R. W., & Russon, A. E. (1998). Learning by imitation: A hierarchical approach. *Behavioral and Brain Science, 21*, 667-721.

Call, J., Carpenter, M., & Tomasello, M. (2005). Copying results and copying actions in the process of social learning: Chimpanzees (Pan troglodytes) and human children (Homo sapiens). *Animal Cognition, 8*, 151-163.

Campos, J. J., Emde, R. N., Gaensbauer, T., & Henderson, C. (1975). Cardiac and Behavioral interrelationships in the reactions of infants to strangers. *Developmental Psychology, 11,* 589-601.

Caporael, L. R., & Brewer, M. B. (1995). Hierarchical evolutionary theory: There is an alternative, and it's not creationism. *Psychological Inquiry, 6*, 31-34.

Carpenter, M., Akhtar, N., & Tomasello, M. (1998). Fourteen- through 18-month-old infants differentially imitate intentional and accidental actions. *Infant Behavior & Development, 21*, 315-330.

Carpenter, M., & Call, J. (in press). Comparing the imitative skills of children and nonhuman apes. *Primatologie*.

Carpenter, M., Call, J., & Tomasello, M. (2002). Understanding "prior intentions" enables two-year-olds to imitatively learn a complex task. *Child Development, 73*, 1431-1441.

Carpenter, M., Nagell, K., & Tomasello, M. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Develompment, 63*, 1-143.

Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: The perception-behavior link and social interaction. *Journal of Personality and Social Psychology, 76*, 893-910.

Chow, V., Poulin-Dubois, D., & Lewis, J. (2008). To see or not to see: Infants prefer to follow the gaze of a reliable looker. *Developmental Science, 11*, 761-770.

Csibra, G. (2008). Goal attribution to inanimate agents by 6.5-month-old infants. *Cognition, 107*, 705-717.

Csibra, G., Bíró, S., Koós, O., & Gergely, G. (2003). One-year-old infants use teleological representations of actions productively. *Cognitive Science, 27*, 111-133.

Csibra, G., & Gergely, G. (2006). Social learning and social cognition: The case for pedagogy. In Y. Munakata & M. H. Johnson (Eds.), *Process of change in brain and cognitive development* (pp. 249-274). Oxford: Oxford University Press.

Csibra, G., Gergely, G., Bíró, S., Koós, O., & Brockbank, M. (1999). Goal attribution without agency cues: The perception of "pure reason" in infancy. *Cognition, 72*, 237-267.

Darwin, C. R. (1859/1981). *On the origin of species by means of natural selection, or the preservation of favoured races in the struggle for life*. Cambridge, MA: Harvard University Press.

Daum, M. M., Prinz, W., & Aschersleben, G. (2008a). Encoding the goal of an object-directed but uncompleted reaching action in 6- and 9-month-old infants. *Developmental Science, 11*, 607-619.

Daum, M. M., Prinz, W., & Aschersleben, G. (2008b). *The interrelation of 6-month-olds' abilities to observe and perform an object-related grasping action.* Manuscript in preparation.

Daum, M. M., Prinz, W., & Aschersleben, G. (2008c). *Means-end behavior in young infants: The interplay of action perception and action production.* Manuscript submitted for publication.

Daum, M. M., Sommerville, J., & Prinz, W. (in press). Becoming a social agent: Developmental foundations of an embodied social psychology. *European Journal of Social Psychology*.

Decety, J., & Grèzes, J. (1999). Neural mechanisms subserving the perception of human actions. *Trends in Cognitive Sciences, 3*, 172-178.

Durham, W. (1991). *Coevolution: Genes, culture, and human diversity*. Stanford: Stanford University Press.

Eckerman, C. O., Davis, C. C., & Didow, S. M. (1989). Toddlers' emerging ways of achieving social coordinations with a peer. *Child Development, 60*, 440-453.

Eckerman, C. O., & Whatley, J. L. (1977). Toys and social interaction between infant peers. *Child Development, 48*, 1645-1656.

Emde, R. N., Gaensbauer, T. J., & Harmon, R. J. (1976). Emotional expression in infancy: A biobehavioral study. *Psychological Issues, 10*, 3-198.

Etaugh, C., Grinnell, K., & Etaugh, A. (1989). Development of gender labeling: Effect of age of pictured children. *Sex Roles, 21*, 769-773.

Fadiga, L., Fogassi, L., Pavesi, G., & Rizzolatti, G. (1995). Motor facilitation during action observation: A magnetic stimulation study. *Journal of Neurophysiology, 73*, 2608-2611.

Fagot, B. I., & Leinbach, M. D. (1989). The young child's gender schema: Environmental input, internal organization. *Child Development, 60*, 663-672.

Falck-Ytter, T., Gredeback, G., & von Hofsten, C. (2006). Infants predict other people's action goals. *Nature Neuroscience, 9*, 878-879.

Fogassi, L., & Gallese, V. (2002). The neural correlates of action understanding in non-human primates. In M. I. Stamenov & G. Gallese (Eds.), *Mirror neurons and the evolution of brain and language* (pp. 13-35). Amsterdam: John Benjamins.

Gergely, G. (2008). Learning 'about' versus learning 'from' other minds. In P. Carruthers (Ed.), *The innate mind* (Vol. 3, pp. 170-199). Oxford: Oxford University Press.

Gergely, G., Bekkering, H., & Király, I. (2002). Rational imitation in preverbal infants. *Nature, 415*, 755.

Gergely, G., & Csibra, G. (2003). Teleological reasoning in infancy: The naive theory of rational action. *Trends in Cognitive Sciences, 7*, 287-292.

Gergely, G., & Csibra, G. (2005). The social construction of the cultural mind: Imitative learning as a mechanism of human pedagogy. *Interaction Studies, 6*, 463-481.

Gergely, G., Nádasdy, Z., Csibra, G., & Bíró, S. (1995). Taking the intentional stance at 12 months of age. *Cognition, 56*, 165-193.

Gergely, G., & Watson, J. S. (1999). Early social-emotional development: Contingency perception and the social-biofeedback model. In P. Rochat (Ed.), *Early Socialization* (pp. 101-137). Hillsdale, NJ: Erlbaum.

Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin.

Goldin-Meadow, S., Goodrich, W., Sauer, E., & Iverson, J. (2007). Young children use their hands to tell their mothers what to say. *Developmental Science, 10*, 778-785.

Goodwyn, S. W., & Acredolo, L. P. (1993). Symbolic gesture versus word: Is there a modality advantage for onset of symbol use? *Child Development, 64*, 688-701.

Goodwyn, S. W., & Acredolo, L. P. (1998). Encouraging symbolic gestures: A new perspective on the relationship between gesture and speech. *New Directions for Child Development*, 61-73.

Goodwyn, S. W., Acredolo, L. P., & Brown, C. A. (2000). Impact of symbolic gesturing on early language development. *Journal of Nonverbal Behavior, 24*, 81-103.

Gould, S. J. (1979). Shades of Lamarck. *Natural History, 88*, 22-28.

Greenberg, D. J., Hillman, D., & Grice, D. (1973). Infant and stranger variables related to stranger anxiety in the first year of life. *Developmental Psychology, 9*, 207-212.

Grusec, J. E., & Abramovitch, R. (1982). Imitation of peers ans adults in a natural setting: A functional analysis. *Child Development, 53*, 636-642.

Guglielmino, C. R., Viganotti, C., Hewlett, B., & Cavalli-Sforza, L. L. (1995). Cultural variation in Africa: Role of mechanisms of transmission and adaptation. *Proceedings of the National Academy of Sciences USA, 92*, 7585-7589.

Hamlin, J. K., Hallinan, E. V., & Woodward, A. L. (2008). Do as I do: 7-month-old infants selectively reproduce others' goals. *Developmental Science, 11*, 487-494.

Hanna, E., & Meltzoff, A. N. (1993). Peer imitation by toddlers in laboratory, home, and day-care contexts: Implications for social learning and memory. *Developmental Psychology, 29*, 701-710.

Hauf, P., Elsner, B., & Aschersleben, G. (2004). The role of action effects in infants' action control. *Psychological Research, 68*, 115-125.

Hayne, H., Herbert, J., & Simcock, G. (2003). Imitation from television by 24- and 30-month-olds. *Developmental Science, 6*, 254-261.

Hegarty, M. (2004). Mechanical reasoning by mental simulation. *Trends in Cognitive Sciences, 8*, 280-285.

Heyes, C. (2001). Causes and consequences of imitation. *Trends in Cognitive Sciences, 5*, 253-261.

Holmes, K. M., & Holmes, D. W. (1980). Signed and spoken language development in a hearing child of hearing parents. *Sign Language Studies, 28*, 239-254.

Hommel, B., Müsseler, J., Aschersleben, G., & Prinz, W. (2001). The theory of event coding (TEC): A framework for perception and action planning. *Behavioral and Brain Sciences, 24*, 849-878.

Horner, V., & Whiten, A. (2005). Causal knowledge and imitation/emulation switching in chimpanzees (Pan troglodytes) and children (Homo sapiens). *Animal Cognition, 8*, 164-181.

Hrdy, S. B. (2007). Evolutionary context of human development: The cooperative breeding model. In C. A. Salmon & T. K. Shackelford (Eds.), *Family relationships: An evolutionary perspective* (pp. 39-68). New York, NY: Oxford University Press.

Huang, C.-T., & Charman, T. (2005). Gradations of emulation learning in infants imitation of actions on objects. *Journal of Experimental Child Psychology, 92*, 276-302.

Huang, C.-T., Heyes, C., & Charman, T. (2002). Infants' behavioral reenactment of "failed attempts": Exploring the roles of emulation learning, stimulus enhancement, and understanding of intentions. *Developmental Psychology, 38*, 840-855.

Iacoboni, M., Molnar-Szakacs, I., Gallese, G., Buccino, G., Mazziotta, J. C., & Rizzolatti, G. (2005). Grasping the intentions of others with one's own mirror neuron system. *PLoS Biology, 3*, E79.

Iverson, J. M., & Goldin-Meadow, S. (2005). Gesture Paves the Way for Language Development. *Psychological Science, 16*, 367-371.

Jaswal, V. K., & Malone, L. S. (2007). Turning believers into skeptics: 3-year-olds' sensitivity to cues to speaker credibility. *Journal of Cognition and Development, 8*, 263-283.

Jaswal, V. K., & Neely, L. A. (2006). Adults don't always know best: preschoolers use past reliability over age when learning new words. *Psychological Science, 17*, 757-758.

Johnson, S. C., Booth, A., & O'Hearn, K. (2001). Inferring the goals of a nonhuman agent. *Cognitive Development, 16*, 637-656.

Jones, S. S. (1996). Imitation or exploration? Young infants' matching of adults' oral gestures. *Child Development, 67*, 1952-1969.

Jones, S. S. (2006). Exploration or imitation? The effect of music on 4-week-old infants' tongue protrusions. *Infant Behavior & Development, 29*, 126-130.

Jones, S. S. (2007). Imitation in infancy: the development of mimicry. *Psychological Science, 18*, 593--599.

Jovanovic, B., Király, I., Elsner, B., Gergely, G., Prinz, W., & Aschersleben, G. (2007). The role of effects for infants' perception of action goals. *Psychologia, 50*, 273-290.

Kinzler, K. D., Dupoux, E., & Spelke, E. S. (2007). The native language of social cognition. *Proceedings of the National Academy of Sciences of the United States of America, 104*, 12577-12580.

Király, I. (2009). The effect of the model's presence and of negative evidence on infants' selective imitation. *Journal of Experimental Child Psychology, 102*, 14-25.

Király, I., Jovanovic, B., Prinz, W., Aschersleben, G., & Gergely, G. (2003). The early origins of goal attribution in infancy. *Consciousness and Cognition, 12*, 752-769.

Klein, A. M., Hauf, P., & Aschersleben, G. (2006). The role of action effects in 12-month-olds' action control: a comparison of televised model and live model. *Infant Behavior & Development, 29*, 535--544.

Kobasigawa, A. (1968). Inhibitory and disinhibitory effects of models on sex-inappropriate behavior in children. *Psychologia, 11*, 86-96.

Koenig, M. A., Clement, F., & Harris, P. L. (2004). Trust in testimony: Children's use of true and false statements. *Psychological Science, 15*, 694-698.

Koenig, M. A., & Echols, C. H. (2003). Infants' understanding of false labeling events: the referential roles of words and the speakers who use them. *Cognition, 87*, 179-208.

Koenig, M. A., & Harris, P. L. (2005a). Preschoolers mistrust ignorant and inaccurate speakers. *Child Development, 76*, 1261-1277.

Koenig, M. A., & Harris, P. L. (2005b). The role of social cognition in early trust. *Trends in Cognitive Sciences, 9*, 457-459.

Kornhaber, R. C., & Schroeder, H. E. (1975). Importance of model similarity on extinction of avoidance behavior in children. *Journal of Consulting and Clinical Psychology, 43*, 601-607.

Kujawski, J. H., & Bower, T. G. R. (1993). Same-sex preferential looking during infancy as a function of abstract representation. *British Journal of Developmental Psychology, 11*, 201-209.

Lakin, J. L., & Chartrand, T. L. (2003). Using nonconscious behavioral mimicry to create affiliation and rapport. *Psychological Science, 14*, 334-339.

Lakin, J. L., Jefferis, V. E., Cheng, C. M., & Chartrand, T. L. (2003). The chameleon effect as social glue: Evidence for the evolutionary significance of nonconscious mimicry. *Journal of Nonverbal Behavior, 27*, 145-162.

Lamarck, J. B. (1809/1990). *Zoologische Philosophie*. Frankfurt am Main: Harri.

Legerstee, M., Anderson, D., & Schaffer, A. (1998). Five- and eight-month-old infants recognize their faces and voices as familiar and social stimuli. *Child Development, 69*, 37-50.

Legerstee, M., & Markova, G. (2008). Variations in 10-month-old infant imitation of people and things. *Infant Behavior & Development, 31*, 81-91.

Lewis, M., & Brooks-Gunn, J. (1975). Infants' social perception: a constructivist view. In L. B. Cohen & P. Salapatek (Eds.), *Infant perception: from sensation to cognition* (Vol. 2, pp. 101-148). New York: Academic Press.

Liepelt, R., von Cramon, D. Y., & Brass, M. (2008). How do we infer others' goals from non-stereotypic actions? The outcome of context-sensitive inferential processing in right inferior parietal and posterior temporal cortex. *Neuroimage, 43*, 784-792.

Liszkowski, U., Carpenter, M., Striano, T., & Tomasello, M. (2006). 12- and 18-month-olds point to provide information for others. *Journal of Cognition and Development, 7*, 173-187.

Liszkowski, U., Carpenter, M., & Tomasello, M. (2007). Pointing out new news, old news, and absent referents at 12 months of age. *Developmental Science, 10*, F1-F7.

Lorenz, K. (1943). Die angeborenen Formen möglicher Erfahrung [Innate forms of potential experience]. *Zeitschrift für Tierpsychologie, 5*, 235-409.

Lubin, L., & Field, T. (1981). Imitation during preschool peer interaction. *International Journal of Behavioral Development, 4*, 443-453.

Luo, Y., & Baillargeon, R. (2005). Can a self-propelled box have a goal ? Psychological reasoning in 5-month-old infants. *Psychologigal Science, 16*, 601-608.

Lyons, D. E., Young, A. G., & Keil, F. C. (2007). The hidden structure of overimitation. *Proceedings of the National Academy of Sciences of the United States of America, 104,* 19751-19756.

Mak, B. S. K. (2005). *Peer imitation in 4-year-old children: Rational or irrational?* Paper presented at the XXVII Annual Conference of the Cognitive Science Society.

McCall, R. B. (1974). Exploratory manipulation and play in the human infant. *Monographs of the Society for Research in Child Development, 39*, 88.

McCall, R. B., & Kennedy, C. B. (1980). Attention of 4-month infants to discrepancy and babyishness. *Experimental Child Psychology, 29*, 189-201.

Meltzoff, A. N. (1988a). Imitation of televised models by infants. *Child Development, 59*, 1221-1229.

Meltzoff, A. N. (1988b). Infant imitation after a 1-week delay: Long-term memory for novel acts and multiple stimuli. *Developmental Psychology, 24*, 470-476.

Meltzoff, A. N. (1995). Understanding the intentions of others: Re-enactment of intended acts by 18-month-old children. *Developmental Psychology, 31*, 838-850.

Meltzoff, A. N. (2005). Imitation and other minds: The "like me" hypothesis. In S. Hurley & N. Chater (Eds.), *Perspectives on imitation: From cognitive neuroscience to social science* (Vol. 2, pp. 55-77). Cambridge: MIT Press.

Meltzoff, A. N., & Moore, M. K. (1977). Imitation of facial and manual gestures by human neonates. *Science, 198*, 74-78.

Meltzoff, A. N., & Moore, M. K. (1989). Imitation in newborn infants: Exploring the range of gestures imitated and the underlying mechanisms. *Developmental Psychology, 25*, 954-962.

Meltzoff, A. N., & Moore, M. K. (1997). Explaining facial imitation: A theoretical model. *Early Development and Parenting, 6*, 179-192.

Morgan, G. (2008, July). *Does baby signing lead to later language development in hearing children? Evidence from deaf signing babies*. Paper presented at the International Congress of Psychology.

Morgan, G., Herman, R., Barriere, I., & Woll, B. (2008). The onset and mastery of spatial language in children acquiring British sign language. *Cognitive Development, 23*, 1-19.

Morrison, H., & Kuhn, D. (1983). Cognitive aspects of preschoolers' peer imitation in a play situation. *Child Development, 54*, 1041-1053.

Mumme, D. L., & Fernald, A. (2003). The infant as onlooker: Learning from emotional reactions observed in a television scenario. *Child Development, 74*, 221-237.

Munakata, Y., Bauer, D., Stackhouse, T., Landgraf, L., & Huddleston, J. (2002). Rich interpretation vs. deflationary accounts in in cognitive development: The case of means-end skills in 7-month-old infants. *Cognition, 83*, B43-B53.

Nadel-Brulfert, J., & Baudonnière, P. M. (1982). The social function of reciprocal imitation in 2-year-old peers. *International Journal of Behavioral Development, 5*, 95-109.

Nadel, J., Guérini, C., Pezé, A., & Rivet, C. (1999). The evolving nature of imitation as a transiatory means of communication. In J. Nadel & G. Butterworth (Eds.), *Imitation in infancy* (pp. 209-234). Cambridge: Cambridge University Press.

Nielsen, M. (2006). Copying actions and copying outcomes: Social learning through the second year. *Developmental Psychology, 42*, 555-565.

Nielsen, M., Simcock, G., & Jenkins, L. (2008). Social engagement and imitation The effect of social engagement on 24-month-olds' imitation from live and televised models. *Developmental Science*, 11, 722-731.

Nielsen, M., & Slaughter, V. (2007). Multiple motivations for imitation in infancy. In K. Dautenhahn & C. L. Nehaniv (Eds.), *Models and mechanisms of imitation and social learning in robots, humans and animals: behavioural, social and communicative dimensions.* Cambridge, MA: Cambridge University Press.

Nyström, P. (2008). The infant mirror neuron system studied with high density EEG. *Social Neuroscience, 3*, 334-347.

Onishi, K. H., & Baillargeon, R. (2005). Do 15-month-old infants understand false beliefs? *Science, 308*, 255-258.

Pasquini, E. S., Corriveau, K. H., Koenig, M., & Harris, P. L. (2007). Preschoolers monitor the relative accuracy of informants. *Developmental Psychology, 43*, 1216-1226.

Paulus, M., Hunnius, S., Vissers, M., & Bekkering, H. (2008). *How rational is imitation in infancy?* Manuscript submitted for publication

Pea, R. D. (1982). Origins of verbal logic: Spontaneous denials by two- and three-year olds. *Journal of Child Language, 9*, 597-626.

Perloff, R. M. (1982). Gender constancy and same-sex imitation: A developmental study. *Journal of Psychology, 111*, 81-86.

Perner, J., & Ruffman, T. (2005). Infants' insight into the mind: How deep? *Science, 308*, 214-216.

Piaget, J. (1962). *Play, dreams, and imitation in childhood.* London: Routledge & Kegan Paul.

Povinelli, D. J., Landau, K. R., & Perilloux, H. K. (1996). Self-recognition in young children using delayed versus live feedback: Evidence of a developmental asynchrony. *Child Development, 67*, 1540-1554.

Prinz, W. (1990). A common coding approach to perception and action. In O. Neumann & W. Prinz (Eds.), *Relationships between perception and action: Current approaches* (pp. 167-201). Berlin: Springer.

Prinz, W. (1997). Perception and action planning. *European Journal of Cognitive Psychology, 9*, 129-154.

Rakoczy, H., Hamann, K., Warneken, F., & Tomasello, M. (2008). *Learning words and rules from peers versus adults*. Manuscript submitted for publication.

Rizzolatti, G. (2005). The mirror neuron system and imitation. In S. Hurley & N. Chater (Eds.), *Perspectives on imitation: From neuroscience to social science* (Vol. 1, pp. 55-76). Cambridge, MA: MIT Press.

Rizzolatti, G., & Buccino, G. (2005). The mirror-neuron system and its role in imitation and language. In: S. Dehaene, G.R. Duhamel, M. Hauser, & G. Rizzolatti (Eds.), *From monkey brain to human brain* (pp. 213-233). Cambridge, MA: MIT Press.

Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. *Annual Review of Neuroscience, 27*, 169-192.

Rochat, P., & Morgan, R. (1995). Spatial determinants in the perception of self-produced leg movements by 3- to 5-month-old infants. *Developmental Psychology, 31*, 626-636.

Rochat, P., & Striano, T. (2000). Perceived self in infancy. *Infant Behavior & Development, 23*, 513-530.

Rothstein-Fisch, C., & Howes, C. (1988). Toddler peer interaction in mixed-age groups. *Journal of Applied Developmental Psychology, 9*, 211-218.

Rowe, M. L., Ozcaliskan, S., & Goldin-Meadow, S. (2008). Learning words by hand: Gesture's role in predicting vocabulary development. *First Language, 28*, 182-199.

Ryalls, B. O., Gul, R. E., & Ryalls, K. R. (2000). Infant imitation of peer and adult models: Evidence for a peer model advantage. *Developmental Psychology, 46*, 188-202.

Sabbagh, M. A., & Baldwin, D. A. (2001). Learning words from knowledgeable versus ignorant speakers: Links between preschoolers' Theory of Mind and semantic development. *Child Development, 72*, 1054-1070.

Sanefuji, W., Hashiya, K., Itakura, S., & Ohgami, H. (2004). Emergence of the understanding of the other's intention: Re-enactment of intended acts from "failed-attempts" in 12- to 24-month olds. *Psychologia, 47*, 10-17.

Sanefuji, W., Ohgami, H., & Hashiya, K. (2005). Infants' preference for infants and adults. In *Proceedings of 2005 4th IEEE International Conference on Development and learning* (pp. 93-95).

Sanefuji, W., Ohgami, H., & Hashiya, K. (2006a). Development of preference for baby faces across species in humans (Homo sapiens). *Journal of Ethology, 10,* 249-254.

Sanefuji, W., Ohgami, H., & Hashiya, K. (2006b). Preference for peers in infancy. *Infant Behavior & Development, 29*, 584-593.

Schunk, D. H., Hanson, A. R., & Cox, P. D. (1987). Peer-model attributes and children's achievement behaviors. *Journal of Educational Psychology, 79*, 54-61.

Schwier, C., van Maanen, C., Carpenter, M., & Tomasello, M. (2006). Rational imitation in 12-month-old infants. *Infancy, 10*, 303-311.

Shirley, L. J., & Campbell, A. (2000). Same-sex preference in infancy: Visual preference for sex-congruent stimuli at three months. *Psychology, Evolution & Gender, 2*, 3-18.

Simon, S., Ditrichs, R., & Speckhart, L. (1975). Studies in observational paired-associate learning: Informational, social, and individual difference variables. *Journal of Experimental Child Psychology, 20*, 81-104.

Slaughter, V., & Corbett, D. (2007). Differential copying of human and nonhuman models at 12 and 18 month of age. *European Journal of Developmental Psychology, 4*, 31-45.

Sommerville, J. A., & Woodward, A. L. (2005). Pulling out the intentional structure of action: The relation between action processing and action production in infancy. *Cognition, 95*, 1-30.

Sommerville, J. A., Woodward, A. L., & Needham, A. (2005). Action experience alters 3-month-old infants´ perception of others' actions. *Cognition, 96*, B1-B11.

Sonnenschein, S., & Whitehurst, G. J. (1980). The development of communication: When a bad model makes a good teacher. *Journal of Experimental Child Psychology, 29*, 371-390.

Spence, K. W. (1937). The differential response in animals to stimuli varying within a single dimension. *Psychological Review, 44*, 430-444.

Sroufe, L. A. (1977). Wariness of strangers and the study of infant development. *Child Development, 48*, 731-746.

Striano, T., Henning, A., & Stahl, D. (2006). Sensitivity to interpersonal timing at 3 and 6 months of age. *Interaction Studies: Social Behaviour and Communication in Biological and Artificial Systems, 7*, 251-271.

Suddendorf, T. (1999). Children's understanding of the relation between delayed video representation and current reality: A test for self-awareness? *Journal of Experimental Child Psychology, 72*, 157-176.

Suddendorf, T., Simcock, G., & Nielsen, M. (2007). Visual self-recognition in mirrors and live videos: Evidence for a developmental asynchrony. *Cognitive Development, 22*, 185-196.

Thelen, E. (1980). Determinants of amounts of stereotyped behavior in normal human infants. *Ethology and Sociobiology, 1*, 141-150.

Thomas, J. H., Due, K. M., & Wigger, D. M. (1987). Effects of the competence and sex of peer models on childrens's imitative behavior. *Journal of Genetic Psychology, 148*, 325-332.

Thompson, D. E., & Russell, J. (2004). The ghost condition: Imitation versus emulation in young children's observational learning. *Developmental Psychology, 40*, 882-889.

Thorpe, W. H. (1956). *Learning and instinct in animals*. London: Methuen.

Tomasello, M. (1996). Do apes ape? In J. Galef & C. Heyes (Eds.), *Social learning in animals: The roots of culture* (pp. 319-346). New York: Academic Press.

Tomasello, M. (1999). *The cultural origins of human cognition*. Cambridge, MA: Harvard University Press.

Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005). Understanding and sharing intentions: The origins of cultural cognition. *Behavioral and Brain Science, 28*, 675-691.

Troseth, G. L., & DeLoache, J. S. (1998). The medium can obscure the message: Young children´s understanding of video. *Child Development, 69*, 950-965.

Troseth, G. L., Saylor, M. M., & Archer, A. H. (2006). Young children´s use of video as a source of socially relevant information. *Child Development, 77*, 786-799.

Uebel, J., Carpenter, M., & Tomasello, M. (2008). *Mimicry increases prosocial behavior in 18-month-olds.* Paper presented at the International Conference of Infant Studies, Vancouver, Canada.

Uzgiris, I. C. (1981). Two functions of imitation during infancy. *International Journal of Behavioral Development, 4*, 1-12.

VanderBorght, M., & Jaswal, V. (in press). Who knows best? Preschoolers sometimes prefer child informants over adult informants. *Infant & Child Development*.

Vygotsky, L. S. (1978). *Mind and society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Want, S. C., & Harris, P. L. (2002). How do children ape? Applying concepts from the study of non-human primates to the developmental study of 'imitation' in children. *Developmental Science, 5*, 1-41.

Waters, E., Matas, L., & Sroufe, L. A. (1975). Infants' reactions to an approaching stranger: Description, validation, and functional significance of wariness. *Child Development, 46*, 348-356.

Williamson, R. A., & Markman, E. M. (2006). Precision of imitation as a function of preschoolers' understanding of the goal of the demonstration. *Developmental Psychology, 42*, 723-731.

Williamson, R. A., Meltzoff, A. N., & Markman, E. M. (2008). Prior experiences and perceived efficacy influence 3-year-olds' imitation. *Developmental Psychology, 44*, 275-285.

Wilson, M., & Knoblich, G. (2005). The case for motor involvement in perceiving conspecifics. *Psychological Bulletin, 131*, 460-473.

Wimmer, H., Hogrefe, G. J., & Perner, J. (1988). Children's understanding of informational access as source of knowledge. *Child Development, 59*, 386-396.

Wolf, T. M. (1973). Effects of live modeled sex-inappropriate play behavior in a naturalistic setting. *Developmental Psychology, 9*, 120-123.

Woodward, A. L. (1998). Infants selectively encode the goal object of an actor´s reach. *Cognition, 69*, 1-34.

Woodward, A. L. (1999). Infants' ability to distinguish between purposeful and non-purposeful behaviors. *Infant Behavior & Development, 22*, 145-160.

Zentall, T. R. (2005). Novelty is an unreasonable requirement for imitated behavior. In S. Hurley & N. Chater (Eds.), *Perspectives on imitation: From mirror neurons to memes* (Vol. 2, pp. 189-191). Cambridge, MA: MIT Press.

Zmyj, N., Daum, M. M., Prinz, W., & Aschersleben, G. (2009). *Infants' attentional preference for object-related actions of older children compared to object-related actions of peers and adults.* Manuscript submitted for publication.

Zmyj, N., Hauf, P., & Striano, T. (2009). *Contingency detection of self produced leg movements in the first year of life*. Manuscript submitted for publication

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Zeitschriftenartikel und Buchkapitel

Zmyj, N., Daum, M.M., & Aschersleben, G. (2009). The development of rational imitation in 9- and 12-month-old infants. *Infancy, 14,* 131-141.

Daum, M. M., Zmyj, N., & Aschersleben, G. (2008). Early ontogeny of action perception and production. In F. Morganti, A. Carassa, & G. Riva (Eds.), *Enacting intersubjectivity: A cognitive and social perspective to the study of interactions* (pp. 175-186). Amsterdam: IOS Press.

Vorträge

Zmyj, N., Daum, M.M., Prinz, W., & Aschersleben, G. (2008). *Imitation of differently aged models in 14-month-old infants.* Paper presented at the International Conference on Infant Studies, Vancouver, Canada.

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Poster

Zmyj, N., Buttelmann, D., Carpenter, M., & Daum, M. M. (2008). *A model's competence influences the imitative behaviour of 14-month-olds.* Poster presented at the 29th International Congress of Psychology, Berlin, Germany.

Zmyj, N., Daum, M. M., & Prinz, W. (2007). *Rational imitation of differently aged models.* Poster presented at the 37th Annual Meeting Program of the Jean Piaget Society, Amsterdam, Netherlands.

Zmyj, N., Daum, M. M., Prinz, W., & Aschersleben, G. (2007*). Infants, older children or adults - which age group is preferably perceived in infancy?* Poster presented at the Biennial Meeting of the Society for Research in Child Development, Boston, MA, USA.

Zmyj, N. & Bischof-Köhler, D. (2007). *Gender constancy and time comprehension in early childhood.* Poster presented at the Biennial Meeting of the Society for Research in Child Development, Boston, MA, USA.

Zmyj, N., Daum, M. M., Prinz, W., & Aschersleben, G. (2006). *Präferieren Kinder im ersten Lebensjahr die Handlungen von Kindern gegenüber den Handlungen von Erwachsenen?* In F. Lösel & D. Bender (Hrsg.), 45. Kongress der Deutschen Gesellschaft für Psychologie (pp. 409-410). Lengerich: Pabst Science Publishers.

Curriculum Vitae

Name:	Norbert Zmyj
Geburtsdatum:	15.02.1980
Geburtsort:	München

Wissenschaftlicher Werdegang

Seit 2005	Promotionsstudium im Hauptfach Psychologie an der Universität Leipzig im Graduiertenkolleg „Die Funktion von Aufmerksamkeit bei kognitiven Prozessen“. Betreuer: Prof. Dr. Wolfgang Prinz; Prof. Dr. Michael Tomasello
2005	Diplom der Psychologie
2005	Diplomarbeit: „Geschlechtsidentität, Theory of Mind und Zeitverständnis. Kognitiver Strukturwandel zwischen dem 4. und 6. Lebensjahr“. Betreuer: Prof. Dr. Doris Bischof-Köhler
2005	Studium der Psychologie an der Universiteit Twente, Niederlande.
2000 – 2005	Studium der Psychologie and der Ludwig-Maximilians-Universität München.

Schule

1999	Abitur
1990 – 1999	Carl-Orff-Gymnasium, Unterschleißheim

Bibliographic Details

Norbert Zmyj

SELECTIVE IMITATION IN ONE-YEAR-OLDS: HOW A MODEL'S CHARACTERISTICS INFLUENCE IMITATION

Universität Leipzig, Dissertation
115 pages; 213 references; 16 figures; 3 tables

This dissertation investigated how characteristics of models influence imitation in one-year-old infants. In particular, we investigated the impact of a model's age when performing novel and familiar behaviour as well as complete and incomplete behaviour. Moreover, we further examined the influence of a model's reliability on imitation.

In Experiment 1 we tested whether infants were able to detect differences in the rationality of a novel action when the models were televised. In Experiment 2 we investigated how a model's age influences infants' tendency to imitate depending on whether novel behaviour (Experiment 2a: illuminating a lamp by using the head) or familiar behaviour (Experiment 2b: performing body movements) were presented. The motivation for conducting Experiment 3 was twofold. The first part of Experiment 3 addressed the question of whether the type of behaviour and time of coding imitative behaviour influenced the findings of Experiment 2b. The second part of Experiment 3 explored how 14-month-olds re-enact failed attempts of familiar object-directed actions from differently aged models. Finally, Experiment 4 investigated whether infants imitate reliable models more often than unreliable models when observing novel behaviour.

To summarise, these results of these experiments indicate that infants are remarkably flexible imitators. Two distinct motivations interact with a model's characteristics in imitation tasks: that is, besides the motivation to learn novel behaviour from reliable adults via imitation, infants use imitation of familiar behaviour in order to interact socially with peers.

Selbständigkeitserklärung

Hiermit erkläre ich, dass die vorliegende Arbeit ohne unzulässige Hilfe und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt wurde und dass die aus fremden Quellen direkt oder indirekt übernommenen Gedanken in der Arbeit als solche kenntlich gemacht worden sind.

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