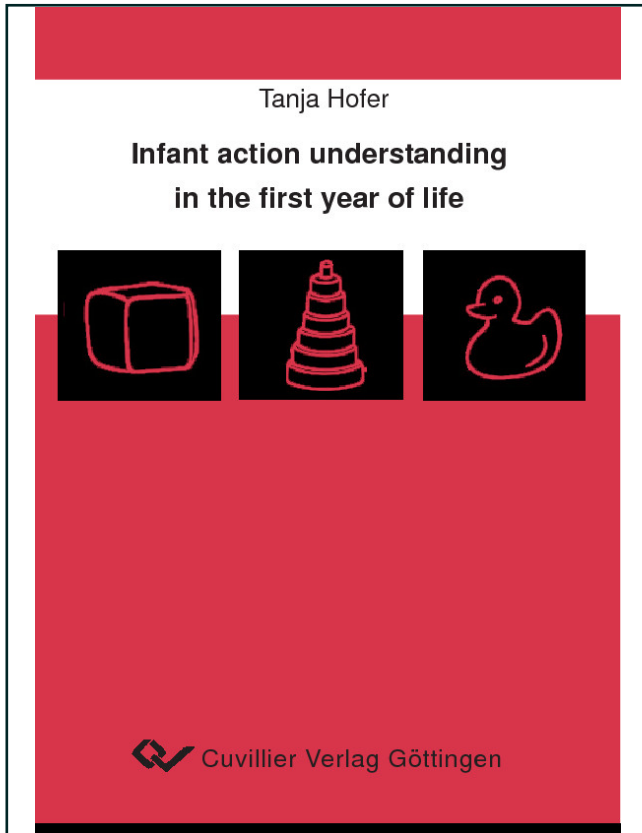




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Infant action understanding in the first year of life



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1 General Introduction

Understanding and interpreting the actions and minds of other people is one of the most challenging tasks for infants and young children in their development. To reason about other's actions in terms of goals forms an important cornerstone in infants' action understanding. Understanding actions as goal-directed enables the interpretation, prediction and the making of further sense of other people's actions and behaviour. This ability to detect that an action is directed toward a goal has been theorised to be among the first elements present in infants' reasoning about people's behaviour, preceding an understanding of intentions and other mental states (Dennett, 1987; Premack, 1990; Wellman, 1992). However, to become a functional member of our world and achieve an adult-like understanding of others' actions and minds, infants have a long way to go.

In fact, as adults we have already gained a rich knowledge that enables us to make sense of our own behaviour as well as of others' behaviour and actions. The knowledge how to reason about and of how to make sense of other's behaviour and actions relies to a great extent on our ability to perceive others as having mental states that guide their behaviour. The ability to perceive others as psychological beings having mental states such as intentions, thoughts, desires, and emotions has been known as "*folk psychology*" or "*Theory of Mind*" (Astington, Harris, & Olson, 1988; Dennett, 1987; Premack & Woodruff, 1978; Wellman, 1992). Attributing mental states to other people is undoubtedly a useful strategy, in that human behaviour becomes meaningful and predictable and in that coordinated social interactions and communication between people becomes possible. Thus, to "survive" in everyday life it is of great importance to develop knowledge about what guides the actions of other people.

Recently in developmental and cognitive psychology, efforts have been made to link the theory-of-mind development to early emerging skills which could count as precursors for a later Theory of Mind in preverbal children. Since intentions are considered as the most fundamental mental states and seen as probably the earliest understandable mental states in development, most of these studies investigate children's ability to reason about persons' intentions. However, it is important to note that while children before 2 years of age are not able to do sophisticated mental state reasoning, they can take into account whether other's behaviour and actions are directed purposefully towards the world. This action knowledge is called intentional action understanding and is in place by the second year of life. A key element of intentional action understanding is the "insight" that the actions of others are

directed toward an end-state, i.e. toward a goal, and this ability can be observed even in the first year of life. In this sense, understanding people's goals allows the transformation of mere bodily motions into meaningful intentional actions (Carpenter, Call, & Tomasello, 2005).

This dissertation deals with the developing ability to interpret the actions of other people as goal-directed in the first year of life. It reports the results of three different research projects on infants' ability to understand others' actions as goal-directed. The common purpose of the projects was to investigate how infants between 6 and 12 months of life develop an understanding of goal-directedness under certain circumstances and which factors might help infants to develop this ability.

This introductory chapter seeks to provide a framework for the following chapters in that it offers a background for the understanding of what infants know about the actions of other people and how and why infants gain knowledge to understand other's actions. This first chapter starts with an overview of the findings from early intentional action understanding. Next, an outline of the concept of action goals and of goal-directedness is specified and findings on infants' understanding of goal-directedness are provided. Then, different theories regarding the early action understanding are briefly expounded. The chapter ends with a description about the goals of the three different research projects and an outline of the dissertation.

1.1 Early intentional action understanding

Considerable research has focussed on the extent to which toddlers and infants have an understanding of intentional actions and provide evidence that by the second year of life they have an understanding of other persons' actions as intentional.

Starting at 2 years of age, toddlers use information about an actor's prior intention to learn problem-solving strategies. Carpenter, Call and Tomasello (2002) asked whether knowing a model's prior intention before the model gives a demonstration influences what children learn from the demonstration. They could show that toddlers who had been informed about the model's intention, imitated a complex action more often and better than children without prior information. In his seminal study, Meltzoff (1995) investigating whether infants understand what a model intends to do, showed that 18-month-olds are able to infer the goal from the surface behaviour, even if it is not perceivable from the model's movement. Infants saw a model who was trying but failing to perform a target action on an object. Instead of just

copying the surface features of the failed attempts, children completed the observed actions. Interestingly, this tendency was only found when the model was a person, but not when a mechanical device modelled the actions. Whilst Bellagamba and Tomasello (1999) replicated this finding for 18- but not for 12-month-old infants, a recently conducted study (Bellagamba, Camaioni, & Colonnesi, 2003) revealed that already by 15 months, infants showed a gradual improvement in their ability to solve the task without, however, reaching the performance of 18-month-olds.

Another imitation study (Gergely, Bekkering, & Kiraly, 2002) with even younger infants showed 14-month-olds a model touching his forehead against the top of a box to turn on a light. For half of the infants, the model's hands were occupied during this action and, for the other half, the model's hands were free during the action. When it was their turn, all infants had their hands free. It was found that infants who saw the hands-free demonstration bent over and touched the box with their heads more often than did infants who saw the hands-occupied demonstration. Gergely and colleagues concluded that in the hands-free condition infants assumed that the model had a good reason, an intention, to use his head, and so they followed. However, if the model's hands were occupied, then infants assumed that the use of the head was necessary, and so they were free to ignore it since they had their own hands free. In this study, therefore, infants understood not only the goal of the model but also that the model rationally evaluated reality before choosing an action plan designed to pursue his goal. Investigating the same age group, however, asking whether infants can distinguish between purposeful and non-purposeful actions, Carpenter, Akhtar and Tomasello (1998) showed that 14-month-olds imitate more actions which were vocally marked as intentional (purposeful: "Yeah! There") compared to actions vocally marked as accidental (non-purposeful: "Uh-oh! Oh dear!"). Thus, in order to guide their own behaviour these infants took into account whether the modelled action was done on purpose or by accident.

In brief, the just presented studies suggest that by the second year of life children achieve a quite sophisticated level of knowledge about other's actions. These findings indicate that already by the first half of the second year infants develop an understanding of intentional actions, distinguish between purposeful and non-purposeful actions and can infer action goals from other people.

1.2 Understanding goal-directed actions in infancy

What about infants' action understanding abilities in the first year of life? Research has also focused on even younger infants' action understanding, investigating a more rudimentary form of intentional action understanding however. As already mentioned, research studying infants younger than 12 months focused on an important precursor to understanding intentional actions i.e. the ability to understand that actions are directed toward a goal. However, to be clear, although the goal of an action can be defined in the sense of an intention preceding the action, the generally used notion of action goal in infancy research means, reasoning about goals in terms of the perceivable outcomes of action, an end-state, without necessarily imputing mental states. Furthermore, the prototype of these actions is goal-directed actions on material objects, or defined as object-directed actions (Phillips & Wellman, in press). It is in this sense that we will talk about goal-directedness in the present and the following chapters.

There are two very recent studies using an interactive methodology to investigate infants understanding that an actor is pursuing a goal. One of these recent studies (Carpenter et al., 2005) demonstrated in an imitation game that infants as young as 12 months of age can use the goals of a model to choose which aspects of the action to copy. Infants in one condition saw a model make a toy mouse hop across a map and end in a toy house, in the other condition, infants saw the same scene, however this time the house had been removed. In the "house condition", infants simply put the mouse into the house, ignoring the hopping, whereas in the "no house condition", infants copied the hopping motion. Thus, infants interpreted the model's action in terms of his final goal. In one condition the final goal was to put the mouse in the house in the other condition the action itself was interpreted as the model's goal.

The other recent study (Behne, Carpenter, Call, & Tomasello, 2005) tracing on Carpenter et al.'s findings (1998) investigated whether within the first year of life infants distinguish purposeful actions from accidental actions. Infants were engaged in a game in which an adult gave them toys across a table. In some trials the adult held up a toy but did not give it over. In some cases this was because he was teasing (unwilling) the infant and in other cases it was because whilst holding out a toy it accidentally dropped (unable). In reaction to these activities, 9-month-olds, but not 6-month-olds, responded with more frustration when the adult was unwilling to hand them the toy than when he was apparently unable to do so. Thus far, 9 months seems the earliest age at which infants first distinguish between purposeful and

accidental actions, knowing that an accidental action will not satisfy the actor's goal. As most of the studies using the habituation-dishabituation paradigm to study young infants' understanding of goal-directed actions are described in the following chapters more extensively, only the main findings of particular influencing studies are reported now.

A series of studies conducted by Gergely and colleagues using the habituation-dishabituation paradigm to investigate infants' understanding of goal-directedness, provide converging evidence that by the end of the first year infants appreciate the goal-directedness of an action and are able to infer the unseen goal of an incomplete action (Csibra, Bíró, Koos, & Gergely, 2003; Csibra, Gergely, Biro, Koos, & Brockbank, 1999; Gergely, Nadasdy, Csibra, & Biro, 1995). They found that 9- and 12-month-old, but not 6-month-old infants interpreted a computer-animated circle when it jumped over an obstacle to approach another circle as being goal-directed, but did not respond in this way to the same path of motion when there was no obstacle present. The authors suggest that 9- to 12-month-olds interpret simple actions as rational and directed at particular goals and in addition, they also take relevant aspects of the situation into account for action interpretation. Tracing on Gergely and colleagues' studies, a recently conducted study (Phillips & Wellman, in press) habituated 12-month-olds to a live actor who reached over a barrier with an arching arm movement, to pick up a ball. In test phase, the barrier was removed and infants were presented with either the same arching arm movement to reach for the ball or with a direct reaching arm movement. Infants looked longer at the event in which the actor performed the now senseless arching arm movement than at the direct reaching event. The authors concluded that their findings complement the Gergely et al.'s study (1995) showing that sensitivity to human object-directed action is established by 12 months of age and that by this age infants recognise human reaching toward objects as goal-directed.

Whereas the above cited studies found evidence that by the end of the first year infants interpret actions as goal-directed, in another series of studies Woodward (1998; 1999) examined even younger infants understanding of human actions as directed toward a goal. She showed that at around 5- to 6 months of age infants become sensitive to the goal structure of familiar human reaching actions. However, she found this sensitivity for action goals only for familiar human grasping movements and not when inanimate entities carried out the action. A recently conducted study (Jovanovic et al., *subm.*) elaborated upon these findings by investigating 6-month-old infant's ability to interpret unfamiliar human actions as goal-directed. Findings showed that salient object-directed action effects could enhance infants' interpretation of unfamiliar human actions as goal-directed but not for actions executed by

and inanimate entity. So far, Sommerville, Woodward and Needham (2005) have even tried to find out whether infants before 6 months are sensitive to human action goals. Investigating 3-month-olds they found that an infant's own action experience prior to seeing another person acting, facilitates their sensitivity to the goal structure in the other's action. In addition, they showed that only few minutes of own action experience lead infants to represent similar observed actions as goal-directed. They concluded that infants' action knowledge might be experience driven and that infants as young as 3 months can rapidly form goal-based action representations.

Taken together, several studies have shown that in the first year of life infants represent other people's actions in terms of the relationship between agents and their goals. Thus, infants as young as 3 to 6 months of age already begin to analyse other's actions in meaningful and structured ways that are important for intentional understanding. By the end of the first year of life, infants can more flexibly interpret observed actions as goal-directed, distinguish between a purposeful and an accidental action and analyse action in terms of its intentional structure.

1.3 Theoretical approaches to early action understanding

The above described studies provide compelling evidence that infants begin to understand that other people's actions are directed toward an observable goal, and that they are sensitive to the intentional structure of others actions from very early on. Thus, much interest regarding the question of how and when infants gain such knowledge has been devoted in the last few years. Several theorists are still struggling with these questions, however the two most prominent accounts of these questions are briefly outlined next.

To one group of accounts belong theorists who propose that infants are born with an abstract and sophisticated system for reasoning about intentional action (e.g., Baron-Cohen, 1995; Gergely et al., 1995; Leslie, 1995; Premack, 1990). According to these accounts, infants are hardwired to understand intentionality and this understanding is viewed as an automatic process that is 'triggered' by actions and agents of a certain kind or by single perceptual or behavioural cues (e.g., self-propelled motion). For example, Gergely, Csibra and colleagues (Csibra et al., 2003; Gergely & Csibra, 2003; Gergely et al., 1995) have proposed that human infants possess an action-interpretation system that is based on a "principle of rational action" or a "teleological stance". Seeing an entity moving rationally to take the shortest, most

efficient way to reach a goal, triggers innate conceptions of rational action, and enables infants to interpret the action as goal-directed. The authors argue that the principle of rational action is part of an initial state psychological reasoning system and infants apply it under all conditions in which they can evaluate rationality. A similar account has been proposed by Baron-Cohen (1995). He assumes that two early innate modules are involved in the perception of action goals and eye gaze direction. One hardwired module is sensitive to stimulus properties like self-propulsion or self-initiated movement, and uses these properties to identify intentional agents with goals and desires. The other hardwired module emerging around 4 months of age allows the construction of dyadic representations of eye behaviour and the representation of perceptual states of agents. Soon after the first birthday, a “shared attention mechanism” emerges, taking the two earlier modules as inputs enabling the construction of triadic representations. As a fourth and last module he proposes a module that specifies the whole range of mental states and which is necessary for the further development of Theory of Mind understanding. In short, these accounts take a rather nativist view of intentionality and assume that knowledge about intentional action is innate and triggered by certain kinds of cues and events.

On the contrary, other theorists take a rather constructivist approach to the development of intentional understanding. According to these accounts it is through learning experiences and cognitive comparison, through learning of association and histories of reinforcement, especially in social triadic interactions, that infants gradually come to understand intentional action (e.g., Barresi & Moore, 1996; Carpenter, Nagell, & Tomasello, 1998; Moore & Corkum, 1994; Tomasello, 1999). Furthermore, most of them assume that initial intentional action knowledge only captures certain action regularities (not deeper mental states), is only applied for some specific agents (e.g. only for humans), and only for some actions, for example, only actions that are clearly directed to objects. For example, Tomasello and colleagues’ (e.g., Carpenter, Nagell et al., 1998; Tomasello, 1995; Tomasello, 1999) general view is that infants begin to understand particular kinds of intentional and mental states in others only after they have experienced them first in their own activity and then use their own experience to simulate that of others. Thus, these authors suggest, that it is not before 9 months of age that infants come to an understanding of intentionality. However, in a recent paper these researchers (Tomasello, Carpenter, Call, Behne, & Moll, in press) constrain this general view, arguing that simple “identification with others” might not be a sufficient basis for the simulation process. They speculate that deeper psychological levels of identification with others enable individuals to simulate the intentional and mental states of others in

analogy with their own mental states. Further they claim that these deeper psychological levels of identification with others also depend on the skills and motivations for interpersonal and emotional dyadic sharing. However, they remain relatively unspecific in elaborating these deeper psychological levels. Other theorists, like Barresi and Moore (1996) propose that infants come to understand intentional action in that they integrate at the same time both, first- and third-person information into an intentional schema. Thus, contrary to Tomasello and colleagues, they emphasise a more combined representation of infants' own intentional relations and those of others. Stemming from this combined representation, infants begin to construct differentiated concepts of themselves and others as agents who act intentionally. However, similar to Tomasello and colleagues, they argue that it is not before 9 months of age, that infants can integrate first- and third-person information and it is not until 18 to 24 months of age that true intentional understanding is achieved. Summing up, these accounts propose that intentional understanding may rely strongly on social experiences with others, assuming that infants detect and learn gradually about intentional actions in such circumstances.

Taken together, although both accounts suggest different proposals concerning the origins of intentional action understanding, there is agreement that infants must be able to detect and recognise meaningful structures in other's actions and thus be able to gain an understanding of intentional action relatively early on in their life.

1.4 Overview and goals of the present research projects

In the following overview the goals of the three different research projects in the present dissertation are described. Here the specific research questions that established the basis for the studies in each individual research project are propounded. Afterwards a brief outline about the chapter division of the present work follows.

The **general goal** of the present research projects was to investigate how infants develop an understanding of goal-directedness under certain circumstances and which factors might help infants develop this ability within the second half of the first year of life. However, the studies within each of the three research projects were designed to elucidate a number of questions.

The questions examined in the **first research project** are expounded next. As outlined above, theorists belonging to the rather nativist view, claim an innate knowledge about action interpretation and suggest that infants attribute goals to a wide range of entities that provide

certain kinds of cues. However, nearly all of the relevant findings about attributing goals to inanimate entities concern infants at around 12 months. Moreover, Woodward (1998) and Jovanovic et al. (subm.) did not find that 6-month-old infants interpret the action of an inanimate entity, that is a mechanical claw, as goal-directed. These findings support the rather constructivist view, that goals are initially attributed to humans only. On the basis of the two competing views about when and to whom infants attribute goals, it was *firstly* investigated whether by the end of the first year, infants are able to interpret the action performed by a mechanical claw as goal-directed. The following two questions were derived from the results of this investigation and aspire to investigate two different explanations for the initial findings separately. Studies with infants have shown that action effects play a crucial role in infants' action interpretation (e.g., Jovanovic et al., subm.) and suggest that salient object-directed effects are important for advanced action interpretation in infancy. Thus, *secondly*, it was investigated whether presenting a more salient object-directed action effect would facilitate the 9-month-old infants' interpretation of the claw's action as being goal-directed. The *third* question explored why infants might interpret the action performed by a mechanical claw as goal-directed at all. The rather alternative hypothesis that infants do not categorise the mechanical claw as an agent rather as a tool that is operated as a means in order to achieve a goal by a human actor was assumed. Thus, giving 9-month-olds more information about the claw as a tool should enable them to interpret the action as goal-directed.

The **second research project** traced the issue of under which specific circumstances young infants are able to interpret a human action as goal-directed. The specific circumstance with which infants in this project were confronted was the television. Thus the general question was whether infants could extrapolate similar information to real world information from television. More specifically, it was examined whether 6-month-old infants could interpret actions performed by an actor on television in the same meaningful way, i.e. goal-directed, as when they perceive the same action performed by a live actor.

Finally, the **third research project** sought to investigate which factors might influence the development of early infant action understanding. Here the particular attention was turned to an external factor - the impact of maternal behaviour on infants developing action understanding. Here it was asked whether the maternal interaction style is related to 6-month-olds developing knowledge that human actions are performed in order to achieve a goal. Fundamentally, whether a specific maternal interaction style may enhance or hamper infants' interpretation of an unfamiliar human action as goal-directed was of particular interest here.