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Children's and adults' use of verbal information to visually anticipate others' actions: A study on explicit and implicit social-cognitive processing

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ABSTRACT

According to recent theories, social cognition is based on two different types of information-processing; an implicit or action-based one and an explicit or verbal one. The present study examined whether implicit and explicit social-cognitive information processing interact with each other by investigating young children's and adults' use of verbal (i.e., explicit) information to predict others' actions. Employing eye-tracking to measure anticipatory eye-movements as a measure of implicit processing, Experiment 1 presented 1.5-, 2.5-, and 3.5-year-old children as well as adults with agents who announced to move to either of two possible targets. The results show that only the 3.5-year-old children and adults, but not the 1.5- and 2.5-year-old children were able to use verbal information to correctly anticipate others' actions. Yet, Experiments 2 and 3 showed that 2.5-year-old children were able to use explicit information to give a correct explicit answer (Experiment 2) and that they were able to use statistical information to anticipate the other's actions (Experiment 3). Overall, the study is in line with theoretical claims that two types of information-processing underlie human social cognition. It shows that these two inform each other by 3 years of age.

1. Introduction

A longstanding claim within developmental and cognitive psychology concerns the existence of two distinct forms of knowledge (e.g., Carey, 2001, 2009; Carpendale & Lewis, 2004; Dienes & Perner, 1999; Pascual-Leone, Grafman, & Hallett, 1994; Piaget, 1952, 1962; Ruffman, 2014; Willingham & Goedert-Eschmann, 1999). These forms have been referred to as implicit and explicit knowledge (e.g., Carey, 2009; Dienes & Perner, 1999), or as practical sensorimotor based and verbal knowledge (Carpendale & Lewis, 2004; Ruffman, 2014).

This differentiation has become particularly prominent in research on the basis of human social cognition. Indeed, long before children are able to reason verbally about the behavior of others, they do understand others on an implicit or action based level (e.g., Behne, Carpenter, Call, & Tomasello, 2005; Daum, Vuori, Prinz, & Aschersleben, 2009; Fawcett & Gredebäck, 2013; Gerson & Woodward, 2014; Krogh-Jespersen, Liberman, & Woodward, 2015; Uithol & Paulus, 2014). Moreover, Theory-of-Mind (ToM) research has shown that children pass explicit, verbal ToM-tasks around 4 years of age (e.g., Sodian, Taylor, Harris, & Perner, 1991; for a review see Wellman, Cross, & Watson, 2001). Yet, nonverbal tasks – often employing gaze measures such as visual anticipations – claimed evidence for earlier competencies (e.g., Clements & Perner, 1994; Onishi & Baillargeon, 2005; Senju, Southgate, Snape, Leonard, & Csibra, 2011; Surian, Caldi, & Sperber, 2007; for a review see Sodian, 2011). On the other hand, individuals with autism spectrum disorders seem to perform well on explicit ToM tasks, while showing inferior performances in implicit measures (Schneider, Slaughter, Bayliss, & Dux, 2013; Schuwerk, Vuori, & Sodian, 2015).

To explain these and similar findings, researchers have pointed to the existence of different knowledge structures. For example, Carpendale and Lewis (2004, 2006) have suggested that young children's social understanding is based on action. That is, their understanding of others consists of practical knowledge, which allows for anticipating others' actions and reacting to it. This form of knowledge has also been stressed in recent action-based accounts on early social cognition (e.g., Allen & Bickhard, 2013; Paulus, 2012; Uithol & Paulus, 2014). Then, by learning a propositional language, children acquire a reflective form of knowledge. This enables them to rely on verbally reflected processes in

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explaining and predicting others' behavior. Notably, this distinction maps well to recent discussions in the action control literature. Here, it has been argued that actions can be (and are) independently controlled from conscious, verbally available processes (Hommel, 2013).

Another example comes from recently formulated dual-systems accounts of social cognition (e.g., Apperly & Butterfill, 2009; DeBruin & Newen, 2012; Frith & Frith, 2008, 2012). For example, Apperly and Butterfill (2009) suggested that humans rely on two types of rather dissociated social-cognitive information processing. One of them, the implicit system, is – by definition – fast, efficient, but inflexible. The other one, the explicit system, is – by definition – slow, cognitively demanding, but open to reflection and correction. In line with these models, it has been shown that adults show implicit signs of mentalizing even when not instructed to reflect about others (Samson, Apperly, Braithwaite, Andrews, & Scott, 2010; Schneider, Bayliss, Becker, & Dux, 2012; Surtees, Apperly, & Samson, 2016; van der Wel, Sebanz, & Knoblich, 2014). All these accounts provided important characterizations of these different kinds of knowledge. However, up to now, the question of how exactly these forms of knowledge interact with each other remains largely unaddressed.

Recent research started to tackle this question empirically. Two studies with adults demonstrated that these implicit processes (as assessed by participants' visual anticipations) can be disturbed when a person performs a dual task with high cognitive load (Schneider, Lam, Bayliss, & Dux, 2012), while explicit instruction has no impact on implicit belief tracking (Schneider, Nott, & Dux, 2014). These findings imply that implicit information processing is not impenetrable, albeit only some factors seem to affect it. This leads to the question, whether and when in human development these two types of information processing can inform each other.

Surprisingly, notwithstanding the strong theoretical claims about a dissociation between explicit and implicit forms of social-cognitive information processing, the field lacks systematic research on whether or not these forms of processing interact with each other (cf. Frith & Frith, 2012). The current study was designed to contribute to this question.

To this end, we investigated by means of an eye-tracking study whether and when in development explicit, verbally based knowledge informs implicit processes of social understanding. More concretely, we examined whether young children and adults are able to use verbally presented information to visually anticipate others' actions. We decided to rely on an action prediction paradigm as previous studies reporting evidence for implicit social-cognitive abilities have relied on anticipatory eye-movements (Schneider, Bayliss et al., 2012; Senju, Southgate, White, & Frith, 2009) and as numerous studies with infants and adults have shown that all age-groups are able to visually anticipate the means and goals of others' actions (e.g., Cannon & Woodward, 2012; Falck-Ytter, Gredebäck, & von Hofsten, 2006; Fawcett & Lizskowski, 2012; Fawcett & Gredebäck, 2013; Gredebäck & Melinder, 2010; Paulus et al., 2011).

In Experiment 1, we presented 1.5-, 2.5- and 3.5-year-old children as well as adults with different actors who verbally announced to move to one of two possible targets. Each target was reachable by a path. We measured whether the participants were able to use the verbally presented information to visually anticipate to the correct path. Evidence that participants fail to rely on verbal information to visually anticipate others' actions would support the claim that implicit and explicit processes do not interact with each other. Experiment 2 was designed to clarify whether children would be able to use verbally presented information to verbally respond to a verbal question about the actor's future action. Experiment 3 served as a control experiment to demonstrate that children are able to use implicitly presented information about an actor's goal to visually anticipate its upcoming action.

2. Experiment 1

2.1. Method

2.1.1. Participants

The final sample included 17 1.5-year-old (mean age = 19.4 months; SE = 0.4), 19 2.5-year-old (mean age = 26.8 months; SE = 0.1), 19 3.5-year-old children (mean age = 43 months; SE = 0.3), and 22 adults (mean age = 24 years; SE = 1.4). Participants came from Munich, Germany. Child participants were recruited from local birth records. Informed consent for participation was given by the children's caregivers. Adult participants were recruited from a student population. Ethic approval was obtained from the local ethics board.

2.1.2. Stimuli

The stimulus material consisted of three introductory movies and ten test movies. All movies had a size of 1280 × 1024 pixels and were created with Adobe CS 5.5 (Adobe Systems Inc., San Jose, CA).

The test movies showed two paths leading from the left side to the right side of the screen. At both ends, a target was located (for an example, see Fig. 1). A transparent occluder overlaid the crossroad between both paths. Following previous studies we introduced an occluder to facilitate anticipatory eye-movements to one of the paths rather than fixations on the moving agent (Kochukhova & Gredebäck, 2007; Paulus et al., 2011). On the left side, an animal agent was standing on the path. Identity of the animal agent and the targets varied in every test movie. At the beginning of the movie, a recorded voice drew the participant's attention to the agent by stating: "Look, the <pig>." Then, the agent wiggled and announced two times that it was going to one of the two targets: "I am going to the house." After this announcement, the occluder turned opaque and the agent started to move. The agent disappeared under the occluder for around 3.5 s and then reappeared at one of the paths to walk to its announced goal. The movie ended with the agent having reached its target and took altogether 17 s. For every of the ten combinations of animal agent and targets, four versions were created to balance, which of the two targets

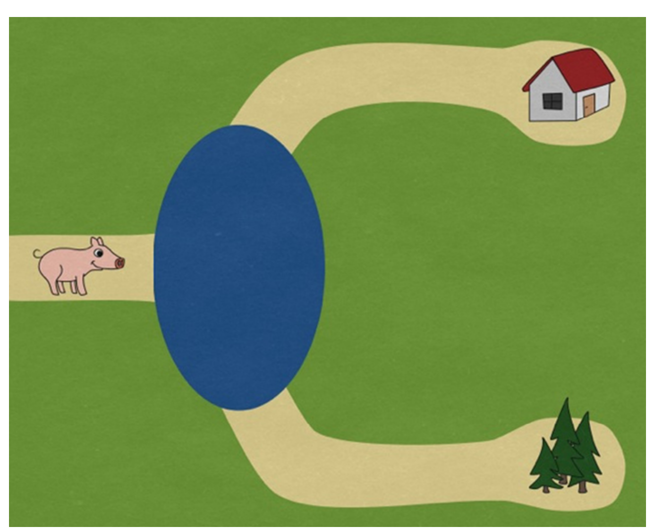

Fig. 1. Example of a test movie. The agent is located at the left side of the screen. The opaque occluder overlies the crossroad between both paths. On the right side, two target objects are located.