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# Children's Developing Understanding of the Subjectivity of Intentions – A Case of "Advanced Theory of Mind"

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**ABSTRACT**

When and how do children develop an understanding of the subjectivity of intentions? Intentions are subjective mental states in many ways. One way concerns their aspectuality: Whether or not a given behavior constitutes an intentional action depends on how, under which aspect, the agent represents it. Oedipus, for example, intended to marry Yocasta, but did not intend to marry his mother (even though in fact, but unbeknownst to him, Yocasta was his mother). In the present study, we investigated the trajectories and determinants of children's developing understanding of (less dramatic forms of) the aspectuality of intentions. In two studies, children aged 3–9 observed an agent who acted intentionally but based on some mis-representation regarding the target of her action. The agent grasped a box that contained A and B while believing that it only contained A but not B. Children were asked about the aspectuality of the agent's intention (in particular, whether she intended to grasp B). When asked to do so spontaneously, children younger than 8 failed (falsely claiming that the agent intended to grasp B). In contrast, in a simplified format in which children were scaffolded through the required inferential chains, children from age 6 succeeded. Children's general capacity for meta-representation appeared to be necessary but not sufficient by itself for understanding the aspectuality of intentions. The present findings suggest that the appreciation of the aspectuality of intentions is part of an advanced theory of mind that develops in much more protracted ways than basic theory of mind.

In the series *Breaking Bad*, the Drug Enforcement Agency (DEA) detective Hank repeatedly talks to his inconspicuous, seemingly innocent brother-in-law Walt about the DEA's strategy in trying to hunt down the infamous Meth cook known by his nickname "Heisenberg." Hank, as almost everyone, believes Heisenberg to be some kind of monster living in a parallel mafia world somewhere out there. As it happens, though, the inconspicuous Walt is in fact Heisenberg. So, Hank in effect reports secret information about the DEA's strategy to Heisenberg himself. Did he do that intentionally? Well, in some broad sense yes, but in a crucial, narrower sense, he did not. While he intended to tell Walt about the DEA's strategy, he clearly did not intend to tell Heisenberg. How is this possible?

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This is possible due to the so-called aspectuality of intentions (Anscombe, 1957; Searle & Willis, 1983): There are always many different descriptions that potentially apply to a given intentional action (such as moving your hand, moving oxygen molecules in the air, waving to a man, greeting your neighbor). But the action is typically performed intentionally only under some specific descriptions or aspects, and not under others. Whether or not a given intentional action description applies, depends on the way the agent represented the action. Intentionality is thus relative to the subjective standpoint of the agent. Such subjective aspectuality is a crucial feature of intentional action. It may come about in various ways: One way is that you actually know about the relevant aspects, but simply do not care about one of them or value another one more strongly. Side effects which are foreseen but not themselves intended by the agent are such a case much discussed in moral philosophy and psychology. Imagine a doctor who gives you a treatment that is the only means to save your life but which will also make you lose your hair. Did she intend to make you bald? In some crucial sense, she did not. She intended to save your life, realized that the only way to do so is to give you the treatment and foresaw (but did not intend to bring about) the side effect of making you bald.

Much more basically, however, the aspectuality of intentional action can be determined by what the agent knows or believes about the relevant situations and her actions. The agent may only have a partial representation of the relevant situation and may be simply unaware of some crucial information. Imagine, for example, A visits a friend B. Sitting in her kitchen while B is in the bathroom, A sees a cookie on the table and eats it. B enters the room and exclaims in shocked voice: "No, tell me you didn't eat my only birthday present!" As it turns out, the cookie was the only birthday present B got this year. So, A intended to eat the cookie but did not intend to eat B's only birthday present – simply because she was unaware of (and would never have been able to think of) this aspect of the cookie.

Another case comes about when the agent does not act on the basis of such partial representations (where an object is both X and Y, but the agent only represents it as X and has no representation regarding the Y-ness), but on the basis of mis-representation (where an object is both X and Y, but the agent believes it is X and believes it is not Y). Our Breaking Bad example above constitutes such a case: Hank represents his interlocutor as being Walt and as not being Heisenberg, and thus intentionally reveals DEA secrets toward him under the description "telling Walt" but not under the description "telling Heisenberg."

From the point of view of cognitive development, the question is when and how children develop a conceptual framework that allows them to understand these complex but foundational features of intentions. Ontogenetically, understanding intentional action develops in degrees and stages over protracted time courses from infancy to school age. Even so much so that some researchers have wondered about a "paradox of intentions": While they are "the simplest and most obvious mental state" whose understanding is indispensable for making sense of any interaction, they are at the same time the state "the most difficult to understand completely" (Astington, 2001, p. 88). Infants from around the end of the first year develop a rudimentary grasp of intentional actions in understanding an agent's goals and distinguishing intentional from unintentional actions (Behne, Carpenter, Call, & Tomasello, 2005; Gergely, Bekkering, & Király, 2002; Meltzoff, 1995; Woodward, 1998). Much later, children from around age four to five begin to develop a more nuanced understanding of intentions that involves, for example, an appreciation of commitment (intentions commit you to performing an action in ways in which a mere desire does not;

Schult, 2002) or the causal self-referentiality of intentions (desires get fulfilled whenever their content is satisfied, but intentions only are fulfilled if they play the right kind of role in bringing it about that their content is fulfilled; Shultz & Wells, 1985).

So, when and how do children acquire a grasp of the subjective aspectuality of intentions? Generally, so far there has been very little research on this question. Initial studies focused on aspectuality based on the agent's *partial representation* of the situation (e.g. Anne intentionally gives the keys to Kathy's dad. Kathy's dad happens to be the policeman, unbeknownst to Anne. So, did Anne intend to give the keys to the policeman?"). Results revealed strikingly late competence: Children answered incorrectly ("yes," in the above example) until age 8 or even later (Kamawar & Olson, 2011). Subsequent studies, however, suggest that these results revealed performance rather than competence limitations and significantly under-estimated younger children's competence. Once a simpler and more engaging method with more relevant content was administered, even 5-year-olds performed competently (Proft, Schünemann, & Rakoczy, 2019).

But what about the more complex case of subjective aspectuality of intentions based on the agent's *mis-representation* of the relevant situations? When and how do children develop an appreciation of this form of aspectuality? This is the topic of the present paper. Inspired by classical Theory of Mind vignettes (Wimmer & Perner, 1983) and more recent variations (Rakoczy, Bergfeld, Schwarz, & Fizke, 2015), we investigate children's representation of scenarios of the following structure: Object A is put in box 1 and object B is put in box 2 in the presence of an agent. Unbeknownst to the agent, A is then transferred to box 2, so that really, both A and B are in box 2 whereas the agent mistakenly thinks that box 2 contains only B and not A. The agent then intentionally grasps box 2 (that, factually, contains both A and B) and the target questions is: did she intend to grasp A? In our scenario, the agent knows about the existence of A and B in the scene. This results in two possible A-related descriptions applicable to the boxes, "contains A"/"does not contain A". The agent then mis-represents box 2 to which she applies "does not contain A" (rather than simply being ignorant regarding A), and her action is performed under that mis-represented description. Accordingly, her action of grasping box 2 is not intentional under the description "contains A." This case where an agent actively thinks that a given description ("take the box that contains A") does not apply to her action is thus different from and more complex than cases of partial representation where an agent is simply ignorant about a potential description under which she acts.

On the basis of this paradigm, we address the following three interrelated questions: First, what is the age of onset of children's appreciation of the aspectuality of intentions based on an agent's mis-representation? Generally, in social cognitive development, an understanding of *what* other agents represent (i.e., whether they represent something) develops before an understanding of *how* they represent something. Regarding visual perspective taking, for example, children from their second year understand whether another agent can or cannot see all the things in a scene that they themselves can see (called "level I perspective-taking"; Flavell, Shipstead, & Croft, 1978). But only from around age 4 do they understand that different agents can see the same thing (e.g., a digit) but see it in different ways depending on their viewpoint (e.g., as a "6" vs. "9") (called "level II perspective-taking"; Flavell, Everett, Croft, & Flavell, 1981). 2-year-olds can thus understand that another agent only has a partial representation of a scene (see objects X and Y, while the child herself sees X, Y and Z). But only 4-year-olds can explicitly understand that

another agent may represent a given scene differently from how they themselves see it, and differently from how it really is and thus mis-represent it (e.g., thinking that a misleading object, actually a rock, was a sponge; Flavell, Green, Flavell, Watson, & Campione, 1986).

Against this background, it is plausible to assume that children's understanding of different forms of the aspectuality of intentions – based on partial representation or mis-representation – follows an analogous trajectory. An understanding of mis-representation-based aspectuality would thus be expected to develop after an understanding of aspectuality based on partial representation. Since previous work has revealed an understanding of this arguably more basic type (aspectuality based on partial representation) in children at age 5, we here tested children from preschool to school age and expected competence in the arguably more complex understanding (aspectual intentions based on mis-representation) not before age 5 or later.

The second question pertains to the more fine-grained courses of development: how does children's understanding of mis-representation in general, and their understanding of the aspectuality of intentions based on an agent's mis-representation relate to each other? Clearly, the former is (conceptually) necessary for the latter. But is it sufficient as well? Theoretically, this is possible: Once children have acquired a general notion of mis-representation, they may flexibly put it to work in different areas, including the understanding of the aspectuality of intentions. Alternatively, a general grasp of mis-representation by itself may not be sufficient for understanding mis-representation-based aspectuality. Developmental trajectories of the latter kind (grasping mis-representation is necessary but not sufficient for some more complex understanding) have been found in related areas: concerning the understanding of complex emotions, it takes children some time after they have acquired a concept of "belief" before they can put this concept to use in ascribing belief-based emotions such as surprise (Hadwin & Perner, 1991; Harris, Johnson, Hutton, Andrews, & Cooke, 1989). Similarly, regarding the development of ascribing higher-order beliefs: it takes children some time (up to two years) after they have acquired a concept of "belief" before they can put this concept to use in recursive ways in the ascription of higher-order beliefs as in "She believes that he believes that p" (Perner & Wimmer, 1985; Sullivan, Zaitchik, & Tager-Flusberg, 1994).

In order to address the second question, we compared children's understanding of the agent's mis-representation (that box 2 contains only B and not A while in fact it contains both A and B) directly to their understanding of the aspectuality of intentions (that the agent intended to grasp the box with B but did not intend to grasp the box with A even though in real fact the box intentionally grasped contained both, A and B).

Third, if understanding mis-representations is indeed necessary but not sufficient for appreciating the aspectuality of intentions, what additional capacities are crucial, and under which conditions can children show such an appreciation? The most obvious candidates are linguistic and domain-general cognitive capacities (working memory and inhibitory control, in particular). Why are these the most obvious candidates? The target tasks clearly pose considerable memory, executive and linguistic demands since children have to remember the agent's subjective viewpoint throughout the narration as well as the different descriptions that apply to the objects in question, and to inhibit their own representations and the urge to answer without considering the particular description. Children's difficulties might also stem from the task's recursive complexity more generally (see Halford, Wilson, & Phillips, 1998). These demands may be particularly prominent in

**Table 1.** Overview of age ranges tested and tasks administered in each sample of Study 1.

| | Study 1 | | |
|---|---|---|---|
| | Sample a | Sample b | Sample c |
| Age Groups in Years | 3 to 6 | 3 to 7 | 8 to 9 |
| Main Task | x | x | x |
| Verbal Intelligence | x | x | |
| Executive Functions | | x | |
| 2nd-order Belief | | x | x |

tasks with complex inferential structure. For example, in the present target tasks children have to engage in the following inferential chain: "She has not seen the transfer of A. Therefore, she believes that A is still in box 1 and box 2 contains only B. Therefore, although she has intentionally taken box 2, since she believed A to be somewhere else, she did not intend to take A." Research with inferentially similarly complex tasks in other areas of social-cognitive development (e.g., moral reasoning or trait ascription) has revealed developmental patterns of the following kind: when required to engage in similar inferential chains spontaneously, even 7-year-olds failed; but when guided through the inferential chain by relevant probes, even 4- to 5-year-olds succeeded (Liu, Gelman, & Wellman, 2007; Proft & Rakoczy, 2019). In the context of the present research, it may thus be possible that children are able to put their understanding of mis-representation to use in coming to understand the aspectuality of intentions more easily under conditions of reduced demands on spontaneous inferences.

Accordingly, we applied two different approaches to address our three research questions. First, we measured children's understanding of aspectuality of intentions in a more spontaneous format in Study 1. For Study 1, we collected three different samples of data (see Table 1) that successively built up on each other. All samples received the same main task, but we extended age windows and conducted additional tasks to be able to address all three research questions. Building on these three samples, Study 1 addressed all three research questions: What is the age of onset and how is its development related to understanding mis-representation? The third research question regarding necessary additional capacities was addressed in a correlational design that assessed the potential role of general cognitive, linguistic and recursive capacities.

The results revealed that only by the age of 8 children grasped the aspectuality of intentions in the spontaneous format. All younger age groups did not show this capacity, even when they had no trouble with understanding mis-representation. This suggests that an understanding of mis-representations is necessary but not sufficient for understanding the aspectuality of intentions based on mis-representation. However, Study 1 failed to find evidence for a crucial role of linguistic, recursive and domain-general cognitive capacities such as working memory and executive function.

Study 2 addressed the third research question with a different approach. By applying a scaffolded format instead of using a correlational design, we manipulated the task structure and thus experimentally reduced linguistic, memory and executive task demands:

Children were guided through the two required sequential inferential steps to correctly answer the target question. Results revealed that in this guided format, even 6-year-olds performed competently and appreciated the aspectuality of intentions.

## Study 1

Study 1 measured children's ability to spontaneously ascribe intentions to an agent who acted on the basis of a mis-representation as well as their ability to ascribe the underlying mis-representations themselves. Children received test questions on structurally similar scenarios that either addressed a protagonist's mis-representation (false belief about an object's location) or her intention based on such a mis-representation. In different conditions, the agent's mis-representation (concerning an object's location) was implemented in different ways: The Two-Objects scenario employed the classical change of location-vignette (Wimmer & Perner, 1983). The One-Object scenario followed a variation of this vignette in which the change of location is observed but happens under an unknown identity (Rakoczy et al., 2015). We collected three different samples that build up on each other in that they addressed open questions of the previous sample. All three samples received the same main task but differed in their age ranges and what additional capacities that were assessed (see Table 1).

### *Method*

#### *Participants*

***Sample a.*** For Sample a, we administered the spontaneous format of our task to address the first two research questions: What is the age of onset of children's appreciation of the aspectuality of intentions based on an agent's mis-representation? And what pattern does the developmental trajectory follow? Children received the main task and the verbal intelligence task. Sample a consisted of seventeen 3-year-olds, sixteen 4-year-olds, seventeen 5-year-olds and sixteen 6-year-olds (39–83 months, M = 60.11 months, SD = 13.30; 35 male). All participants were recruited from local childcare centers and from a databank of children whose parents had previously given consent to experimental participation. One 3-year-old participant was tested but had to be excluded from analysis because she was uncooperative.

***Sample b.*** For Sample b, we administered the same spontaneous task but also included 7-year-olds. To address the third question concerning the crucial additional capacities, children received, in addition to the verbal intelligences task, established tasks which measured their working memory and inhibitory control. To see whether children's difficulties relate to the task's recursive complexity we also assessed children ability to ascribe $2^{nd}$-order beliefs. Sample b consisted of seventeen 3-year-olds, seventeen 4-year-olds, seventeen 5-year-olds, seventeen 6-year-olds, seventeen 7-year-olds (36–95 months, M = 66.26 months, SD = 16.96; 35 male). Four further children were tested but excluded from analysis because they were uncooperative (n = 3) or due to experimental errors (n = 1).

***Sample c.*** We collected a third sample of 8- and 9-year-olds to further extend the age range.[1] These data were collected at a later stage because of the poor performance of the age groups originally included. Since not even 7-year-olds' performance on the intention test question exceeded chance performance, we extended the age window to 8- and 9-year-olds. Due to the COVID pandemic-related testing restrictions, these children could only be tested online. This restricted us to administering the main task and the 2nd-order belief question. The measures for linguistic and cognitive capacities were not adapted to an online version. This sample consisted of seventeen 8-year-olds and seventeen 9-year-olds (96–118 months, M = 106.59 months, SD = 7.03; 15 male). One further 9-year-old was tested but could not be included in the analyses because of technical issues.

## Design and procedure

In a mixed design, with Age Group as between subjects factor, and Scenario (Two-Objects or One-Object) and Test Question (Belief or Intention) as within-subjects factors, each child received eight trials (order counterbalanced): two per combination of Test Question and Scenario. Furthermore, in Samples a and b, we measured children's verbal intelligence as a covariate. Children in Sample b also received working memory and inhibitory control tasks, and children in Samples b and c received the 2nd-order false belief test question.

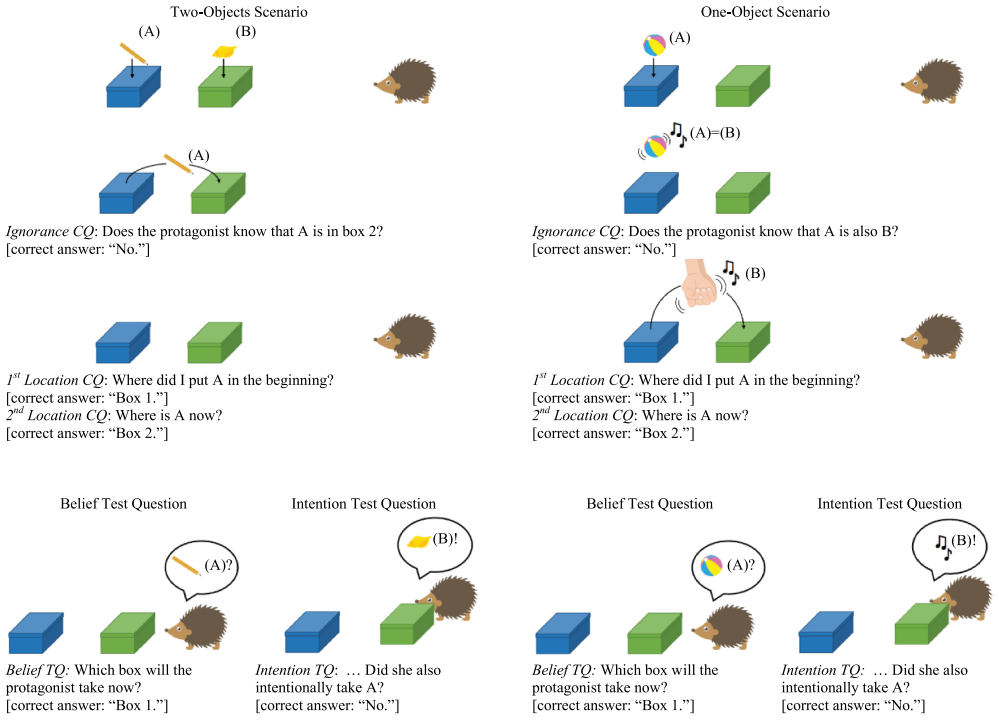


**Figure 1.** Procedure.

[1]We thank the anonymous reviewer for bringing up the idea of extending the age range even further.

### Main task

***Scenarios.*** Following classical Theory of Mind vignettes (Wimmer & Perner, 1983) and more recent variations (Rakoczy et al., 2015), we included two different scenarios (see Figure 1 for an overview of the procedure): In the Two-Objects condition (following Wimmer & Perner, 1983), there were two objects A and B. In the presence of the protagonist, A was put in box 1 and B was put in box 2. In the absence of the protagonist, object A was then transferred to box 2. The protagonist thus came to hold the false belief that A was still in box 1. In the One-Object condition (following Rakoczy et al., 2015) there was an object with two identities A and B, and the agent only knew about one identity (A) but not about the other one (B). The object was put into box 1 under its A-aspect, and then transferred under its B-aspect to box 2. The protagonist thus came to hold the false belief that A was still in box 1. To ensure that children had followed the scenario, we asked control questions about the protagonist's ignorance of the object's new location (Two-Object scenario)/second identity (One-Object scenario) and A's initial and current location. Incorrect answers to control questions were corrected.

***Test questions.*** In half of the test trials, the scenario was followed by a belief test question. In the other half, it was followed by an intention test question. In the belief test trials, the protagonist stated the desire to play with A and children were asked the belief test question.

Belief test question: Which box will the protagonist take now? (correct answer: "Box 1.")

In Samples b and c, we also asked a 2nd- order false belief test question (following Perner & Howes, 1992):

*2nd-order Belief TQ*: If we ask the protagonist: Do you know where A is? What will she say? Will she say, "Yes, I know that" or "No, I don't know that"?

Even though the protagonist mis-represents A's location, she believes she represents it accurately. Thus, the correct answer was "Yes, I know that."

Note, that we only administered the 2nd-order belief test question to children who had mastered the respective 1st-order question. This was possible as the 2nd–order test question was asked within the same trial as the 1st-order question. The reason behind this was to avoid false positives: If a child was unable to ascribe the belief to the agent, she cannot ascribe a belief about this belief. Accordingly, a correct answer in such a case would display chance and not competence.

In the intention test trials, the protagonist stated the desire to play with B (since B never changed its location, the protagonist knew it was in box 2). She then took box 2 and the experimenter asked the intention test question (see Figure 1).

*Intention test question*: The protagonist intentionally[2] took the box containing B. The box also contains A. Did she also intentionally take A? (correct answer: "No.")

To validate the task and ensure that our task analysis fits with mature folk psychology, we administered a paper pencil version of the task to 24 adults. In line with the task analysis, all adults replied "No" to the intention test question (see Supplementary Material, Paper Pencil Version for Adults, for a detailed description of methods and results).

For our online version for Sample c, we adapted the material of the adults' version of the main task. Children saw videos of the main task, which used the same material and followed the same procedure as the acted-out version younger children received (see Supplementary Material, Online Version for 8- and 9-year-olds).

### Linguistic and domain-general cognitive capacities

Moreover, we assessed children's Verbal Intelligence (Samples a and b) as well as their Working Memory and their Inhibitory Control (Sample b). More detailed descriptions of the tasks and psychometric principles can be found in the Supplementary Material (Measures Linguistic and Cognitive Capacities).

***Verbal intelligence.*** Children's Verbal Intelligence was assessed via the vocabulary subtest of the Kaufman Assessment Battery for Children II (KABC) (Melchers & Preuß, 2009). This test requires children to label increasingly difficult objects.

***Working memory.*** To tap children's working memory, we conducted the Color Span Backwards task (Zoelch, Seitz, & Schumann-Hengsteler,). This task requires children to remember a sequence of visually presented colors and to then reproduce these colors in the opposite order.

***Inhibitory control.*** As a measure of inhibitory control, we used the Head-Toes-Knees-Shoulders task (Ponitz et al., 2008), in which children are instructed to respond to the experimenter's requests in the opposite way. Hence, when the experimenter tells the child to touch her head, she has to inhibit abiding by this request and to touch her toes instead.

## Results & discussion

### Scoring

Study 1 required children to ascribe beliefs and intentions to a protagonist who mis-represented the location of an object in a spontaneous format. To show an understanding of beliefs, children had to acknowledge that the agent acted on her mis-representation (false belief) and thus looked for object A at the wrong location (box 1). To show an understanding of the aspectuality of intentions, children had to acknowledge that the

[2]In German, we employed the expression "absichtlich." In contrast to the English expression "intentionally," which has a rather stilted connotation, the German absichtlich belongs to common speech. A translation that lexically is slightly different but that depicts its acceptation more appropriately would be "on purpose." Correspondingly, preschool-aged children in other studies handled the expression correctly when describing the intentionality of action (e.g., for the knee-jerk reflex; Lang & Perner, 2002).

agent did *not* intend to take the object under the description "A." Overall, children received four trials per test question. In each case, two trials referring to a Two-Objects scenario and two trials referring to a One-Object scenario. Correct answers were scored with 1 and incorrect with 0. Accordingly, for each test question children could receive a score between 0 and 4.

The 2nd-order belief test question was scored as correct if children answered "Yes" (stating that the agent falsely believes her belief about the object's location to be true). Remember, we only administered the 2nd-order question when children had answered the respective 1st-order question correctly. All other 2nd-order belief trials were scored as missing values in the main analyses (though, see below for an alternative, more conservative analysis in which children who failed the 1st-order question were scored as failing the 2nd-order question as well).

The KABC allowed children to receive a verbal intelligence-score between 0 and 39,

**Table 2.** Overview of the research questions which the sub-samples of Study 1 addressed and the corresponding measures.

| | | Study 1 | | |
|---|---|---|---|---|
| | | Sample a | Sample b | Sample c |
| 1. Age of onset | ANOVA | x | x | |
| | Chance-comparisons | x | x | x |
| 2. Developmental trajectory | Correlational analyses | x | x | |
| 3. Additional factors | Verbal intelligence | x | x | |
| | Working memory | | x | |
| | Inhibitory control | | x | |
| | 2nd- order belief | | x | x |

according to the number of objects they had labeled correctly. For working memory children could score between 0 and 24 according to the number of correctly revised color sequences. For inhibitory control they could score between 0 and 60 according to the number of movements they transformed correctly (see Supplementary Material for a more detailed description of the scoring and range of obtained scores, Measures Linguistic and Cognitive Capacities).

### *Plan of analysis*

In Study 1, we addressed the three research questions of this paper in the following way. The first question concerns the age of onset of children's appreciation of the aspectuality of intentions based on an agent's mis-representation. To answer this question, we conducted an analysis of variance (ANOVA) on all 3- to 7-year-olds (Samples a and b). In a second step, we compared each age group's performance against chance performance. This was also done for the 8- and 9-year-olds who were tested online. The second question we addressed was how children's understanding of mis-representation and their understanding of the aspectuality of intentions relate to each other. Here, we compared the intention ascriptions of 3-to-7-year-olds who had shown a general understanding of mis-representation to those who had not. Next, we tested whether the relation of age and intention ascriptions were different in these two groups. To address the third question what other capacities are crucial in addition to understanding mis-representation, we looked more closely at the relation

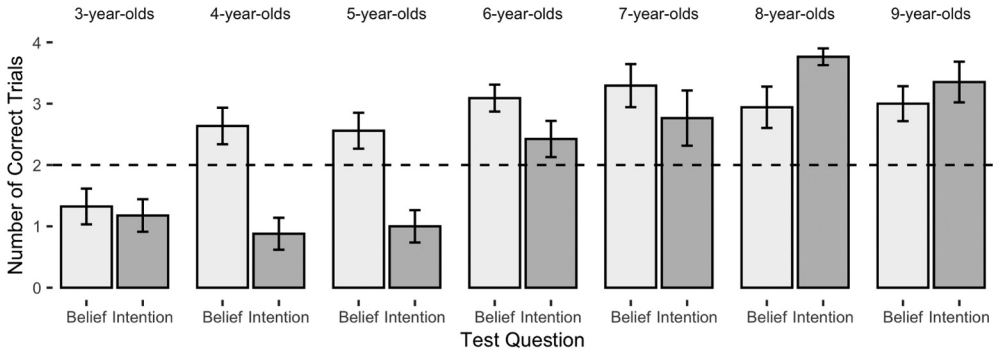


**Figure 2.** Mean number of correctly answered trials out of four. The dashed line depicts chance performance. Error bars depict ± 1 standard error.

between age and intention ascriptions for belief passers. We tested whether verbal intelligence, working memory or inhibitory control mediated this relation. Regarding children's 2nd-order belief reasoning, we asked whether the appreciation of the aspectuality of intentions is similarly impeded by processes as recursive complexity. For this reason, we tested for the correlation of the two tasks. In the following, we report the analyses as a function of the question they mainly speak to. For each analysis, we used all samples for which these data had been collected (see Table 2 for an overview).

### *Age of onset*

The mean numbers of trials in which children gave correct answers as a function of age and test question are depicted in Figure 2 for all three Samples. As our first step of analyses, we conducted a 5 (Age) x 2 (Test Question) x 2 (Scenario) ANOVA with number of correct trials as dependent variable on Sample a and b (Separate analyses of both samples yielded similar results and can be found in the Supplementary Material, Separate Analyses for Sample a and Separate Analyses for Sample b). We included all interactions and main effects in our model.

Because of the ordinal data level of the dependent variable (number of correct trials) and because Shapiro-Wilk normality test showed that data were not normally distributed ($W$= 0.680, $p$< .001), we conducted the ANOVA on aligned rank transformed data using the ARTool (Kay & Wobbrock, 2020). This procedure allows robust non-parametric analyses of interaction and main effects (Wobbrock, Findlater, Gergle, & Higgins, 2011). Results revealed an interaction effect between age and test question ($F$(4, 438) = 7.865, $p$< .001, $\eta^2$ = .04[3]) and a main effect for test question ($F$(1, 438) = 53.885, $p$< .001, $\eta^2$ = .07) and age ($F$(4, 146) = 11.337, $p$< .001, $\eta^2$ = .11). There were no other significant effects (all $F$s <3.474, all $p$s > .063; see Supplementary Material, Complete Output ANOVA Study 1, for detailed statistical values). Post-hoc Kruskal Wallis tests on the Age*Test Question interaction effect showed that children's performance increased with age for both test questions (belief: $\chi^2$ (4) = 21.295, $p$< .001, $\varepsilon^2$ = 0.142; intention: $\chi^2$ (4) = 25.122, $p$< .001, $\varepsilon^2$ = 0.167).

[3]These are effect sizes based on non-transformed data. The ARTool package does not cover effect sizes, yet. However, effect sizes based on non-transformed data approximate the effect sizes based on aligned rank transformed data (Kay, 2020).

Thus, in general children performed worse on the intention than on the belief test questions. For both test questions, performance increased over age. The type of scenario, Two-Objects or One-Object, had no influence on children's performance.

So, at which age do children ascribe the intentions correctly? We tested each age group's performance on the intention test question against chance performance (two out of four trials). In accordance with data level and distribution, we conducted one-sample Wilcoxon signed-rank tests. Results indicated that children of no age group of the 3- to 7-year-olds performed significantly above chance. The performance of 3- to 5-year-olds was even below chance (3-, to 5-year-olds: all $V$s<114.5, all $p$s<.010; 6- and 7-year-olds: all $V$s>280, all $p$s≥.134). Thus, none of the these age groups showed proficient performance on the intention test questions. Indeed, analyses of individual performance patterns show that even in the age group of 7-year-olds 29% (5 out of 17) of children still consistently failed the intention task (see Table 3).

For this reason, we also tested 8- and 9-year-olds in an online adaptation of our task. We found that both of these older age groups performed above chance (8-year-olds: $V$= 136, $p$< .001; 9-year-olds: $V$= 118, $p$= .004)

Thus, regarding our first question (age of onset of appreciating the aspectuality of intentions), Study 1 found that in the spontaneous format children ascribed intentions proficiently only by the age of eight.

### *Developmental trajectory*

We compared two plausible options: Understanding mis-representation is only necessary but not sufficient, or necessary and sufficient for understanding the aspectuality of intentions. For this reason, we compared 3- to 7-year-olds' performance on the intention test question of children who showed a reliable understanding of mis-representation to those who did not. As criterion for the reliability of understanding mis-representation we used children's performance on the belief test question. Children who had given correct answers to all four belief test questions were taken to have already obtained a reliable belief understanding (belief passers, $N$= 75). In contrast, we attributed an unreliable belief understanding to children who failed on one or more belief test questions (belief non-passers, $N$= 76). We then compared children's performance on the intention test question between belief passers and belief non-passers via a non-parametric Mann–Whitney U test. We found no differences in children's intention understanding depending on their belief understanding: Belief passers' ($M$= 1.693, $SD$ = 1.808) and belief non-passers' ($M$= 1.329, $SD$ = 1.644) performance on the intention test question did not differ significantly ($W$= 3130.5, $p$= .259).

**Table 3.** Contingencies age x performance intention test question.

| | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 3-year-olds ($n$= 34) | 18 (53%) | 5 (15%) | 4 (12%) | 1 (3%) | 6 (18%) |
| 4-year-olds ($n$= 33) | 23 (70%) | 1 (3%) | 4 (12%) | 0 (0%) | 5 (15%) |
| 5-year-olds ($n$= 34) | 22 (65%) | 1 (3%) | 4 (12%) | 2 (6%) | 5 (15%) |
| 6-year-olds ($n$= 33) | 8 (24%) | 3 (9%) | 4 (12%) | 3 (9%) | 15 (45%) |
| 7-year-olds ($n$= 17) | 5 (29%) | 0 (0%) | 0 (0%) | 1 (6%) | 11 (65%) |
| 8-year-olds ($n$= 17) | 0 (0%) | 0 (0%) | 1 (6%) | 2 (12%) | 14 (82%) |
| 9-year-olds ($n$= 17) | 2 (12%) | 0 (0%) | 1 (6%) | 1 (6%) | 13 (76%) |

Depicted is the number of children in each age group who succeeded on the according number of intention test question trials. Proportions in relation to the overall number children per age group are shown in brackets.

Thus, children's understanding of mis-representation alone did not determine whether they could appreciate the aspectuality of intentions. The former may thus be necessary but is not sufficient for the latter.

At first glance, it may appear surprising that children who are capable of ascribing beliefs in principle, have such a hard time applying this conceptual capacity in their evaluation of an action as (un-)intentional. However, such developmental trajectories are common in many areas: A given conceptual capacity (like understanding mis-representation) is of substantial importance for the acquisition of some related capacity (like intentionality judgments) but does not do the job alone. Other capacities are required in addition that develop only with progressing age. So, what would be evidence for such a necessary-but-not-sufficient pattern in the present case? One indicator could be different relations with age. The logic is the following: If the developmental trajectory follows indeed a necessary but not sufficient pattern, an appreciation of aspectuality of intentions should not come into play immediately after an understanding of mis-representation. Understanding mis-representation is the basis. But other additional factors have to come into place over time before children can consider mis-representations. Thus, only with increasing age should children (developing additional factors) become more and more able to use their insights about mis-representations for appreciating the aspectuality of intentions. Accordingly, only for those children who understand mis-representation (belief passers) we should observe that mastery of the intention question increases with age. In contrast, the progressing development of these additional factors should have no impact on the mastery of the aspectual intention question of children who do not yet understand mis-representations (belief non-passers), since they fail to fulfill the central necessary prerequisite. Thus, for non-passers there should be no relation between age and intention ascription.

Therefore, we looked at the correlation of age and performance on the intention test question separately for belief passers and belief non-passers. Again, we employed a non-parametric method and conducted Spearman's correlations on children's age in months and the aggregated score of their performance on the intention test question (see Figure 3). The correlation did only reach significance for the belief passers ($r_s(75) = .517$, $p < .001$) but not for the belief non-passers ($r_s(76) = .042$, $p = .716$). Both correlations were significantly

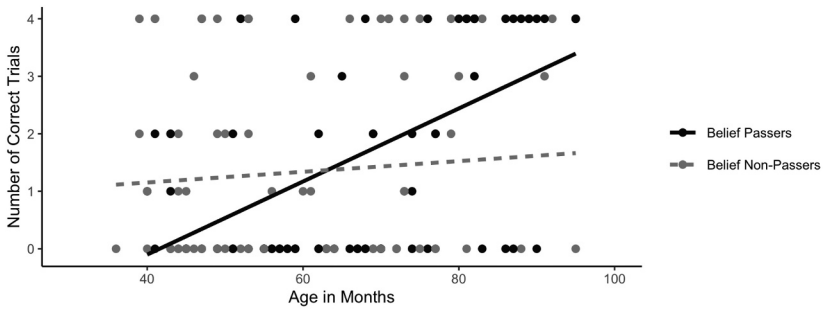


**Figure 3.** Separate correlations between age and performance on the intention test question for belief non-passers and non-passers.

different ($z$= 3.191, $p$< .001). Accordingly, only for those children who already had obtained a reliable understanding of mis-representation, we found that the older they were the better they performed in response to the intention test question.

Thus, regarding our second question, i.e., the developmental trajectory of understanding mis-representation and understanding aspectuality of intentions, Study 1 revealed an interesting pattern. Understanding mis-representation alone did not determine children's ability to consider mis-representations when ascribing intentions. However, for children who had obtained a reliable understanding of mis-representation, intention ascriptions improved with age. Thus, it seems that an understanding of mis-representation is the necessary first step in development. But understanding mis-representation alone is not sufficient. Other factors need to come in place over time as indicated by the better performance of older children. And then, these other factors seem to enable children to apply their knowledge about an agent's mis-representation when they ascribe intentions to her. But what exactly are these factors? This brings on our third question: If understanding mis-representations is indeed necessary but not sufficient for appreciating the aspectuality of intentions, what additional capacities are crucial, and under which conditions can children show such an appreciation?

### *Additional factors*

To address this question, we first looked more closely at the relation between age and performance on the intention test question for those children who already showed a reliable understanding of mis-representation (Sample b). We conducted Sobel tests to see whether children's scores for verbal intelligence, working memory or inhibitory control mediated the relation between age and intention ascription. None of these tests was significant (all $|z|$s ≤ 0.824, all $p$s≥.410). Thus, none of these capacities mediated this relation.

Next, we looked at 3- to 7-year-olds' performance on the intention test question and the 2$^{nd}$-order belief test question (Sample b). Both tasks require similar processing steps: First, ascribe the false belief and then, based on that insight, compute the 2$^{nd}$-order belief or intention. If it was this similar recursive complexity that makes both tasks complicated we should find that they are correlated. We tested for the correlation of these two tasks via multiple regressions. This relation was significant ($b$= 1.12, $t$= 2.39, $p$= .020). However, as soon as age was entered as a second predictor the relation did not reach significance anymore ($b$= 0.51, $t$= 1.03, $p$= .306). The model including age also had a better fit ($F$(1, 61) = 13.77, $p$< .001).[4] Likewise, there was no relation between intention and 2$^{nd}$-order belief ascription for the 8- and 9-year-olds tested online (Sample c), irrespective of whether we controlled for age or not (not controlling for age: $b$= 0.236, $t$= 0.453, $p$= .654; controlling for age: $b$= 0.393, $t$= 0.526, $p$= .461).

[4]Remember, if a child did not answer the 1$^{st}$-order question correctly we did not administer the 2$^{nd}$- order question, and such cases were coded as missing values. Alternatively, however, one could argue that answers in such cases can only be wrong (logically the 2$^{nd}$-order question can only be correctly answered if the 1$^{st}$-order question has been answered correctly), and that these cases should thus be coded as "incorrect" with regard to the 2$^{nd}$-order question. An analysis based on this alternative coding scheme yielded a similar pattern of results. The relation of 2$^{nd}$-order belief and intention ascriptions was significant ($b$= 1.56, $t$= 3.68, $p$< .001), but not if age was included as second predictor ($b$= 0.89, $t$= 1.96, $p$= .053). Again, the latter model explained significantly more variance ($F$(1, 82) = 10.31, $p$= .002).

## Discussion

Regarding our first question, the age of onset of appreciating the aspectuality of intentions, Study 1 showed that only by the age of eight children were able to correctly ascribe intentions spontaneously. While children's performance increased with age, the performance of younger children did not exceed chance. It appears that the spontaneous appreciation of the aspectuality of intentions develops in rather protracted ways.

Regarding our second question, the developmental trajectory of understanding mis-representation and appreciating the aspectuality of intentions, Study 1 clearly points toward a necessary but not sufficient pattern of development. We found that only children who had already obtained an understanding of mis-representation, showed an increase over age in ascribing intentions correctly. No such relation was found for children who have not yet obtained an understanding of mis-representation. This indicates that once children have developed an understanding of mis-representation, some other capacity has to develop first, before children can consider the aspectuality of intentions.

Regarding our third question, what additional crucial factors are necessary for an appreciation of the aspectuality of intentions, we did not find conclusive evidence. We investigated the most obvious candidates, working memory, inhibitory control and verbal intelligence. None of them could explain what enables children to apply their understanding of mis-representation when ascribing intentions. Note, however, that we only had these data for 3- to 7-year-olds. None of these age groups performed proficiently in ascribing intentions. It is thus possible that these results would be different once sufficiently proficient performers were included that cause more variance in our data. Neither for 3- to 7-year-olds nor for the 8-and 9-year-olds tested online, the demands of appreciating the aspectuality of intentions were related to the recursive nature of 2$^{nd}$-order belief ascription. Thus, Study 1 did not find any evidence for any specific additional factors that were crucial for an appreciation of the aspectuality of intention.

But what then causes this "necessary but not sufficient"-trajectory? Another way to approach our third question is to look for conditions under which children show an appreciation of the aspectuality of intentions. One way to realize such an approach is by manipulating task demands, for example related to inferential complexity. The present intention ascription task has a very complex inferential structure. In the spontaneous format of Studies 1, children had to first infer the agent's mis-representation ("She believes that A is still in box 1"). In a second step, they had to ascribe the intention on the basis of the agent's mis-representation ("She intentionally took the box that in fact contained A. But since she believes that A is still in box 1, she did not intend to take the box with A."). Previous empirical work in the domains of moral reasoning and trait ascriptions identified parallel inferential demands. Several studies found that guiding children through the inferential chain revealed much earlier competence (Liu et al., 2007; Proft & Rakoczy, 2019).

## Study 2

The rationale of Study 2 was to test when children reveal competence in aspectual intention ascription tasks once the task demands have been radically reduced. Following similar work in other domains, we adapted the intention ascription task in Study 2 and scaffolded children through the requisite inferential chains. Leading children in a step-wise manner through the components of this chain relieves them from having to process and remember all the information at once. This reduces the cognitive load and demands on working memory. Also, the reassurance might play an important role: It allows children to arrive at final conclusions for each step. This in turn reduces the amount of information that has to be stored, and also alleviates inhibitory demands (since earlier, overridden beliefs need not be inhibited anymore).

### Method

#### Participants

Twenty-one 4-year-olds, eighteen 5-year-olds, twenty 6-year-olds and twenty 7-year-olds (48–96 months, $M$= 71.47 months, $SD$ = 14.14; 37 male) were recruited from the same databank as in Study 1. Children who had participated in one of the earlier studies did not participate again. One further 4-year-old has been tested but was excluded from analysis because he was uncooperative.

#### Design and procedure

A 4 (Age group: 4-, 5-, 6- or 7-year-olds) x 2 (Scenario: Two-Objects or One-Object) x 2 (Test Question: Belief or Intention) mixed design was conducted, with Test Question and Scenario as within-subjects factors. Children received four intention trials but only two belief trials, one per scenario. To be able to see the genuine impact of the scaffolding modification, belief trials were always administered after the intention trials. As in Study 1, the verbal intelligence task (KABC) was always conducted at the beginning of each session.

#### Main task

*Scenarios and test questions.* Children observed the same scenarios as in Study 1. They also received the same test questions with one exception in the intention trials: Before we asked the intention test question, we reminded them of the agent's mis-representation by asking them "Where does the protagonist believe that A is?" Incorrect answers to this question were corrected (and correct answers were confirmed in order to keep the amount of feedback constant irrespective of performance).

### Results

Study 2 focused on the question under which conditions children display an appreciation of the aspectuality of intentions. For this reason, we conducted an ANOVA on their performance on the intention test questions and compared each age group's performance against chance performance. Next, we compared the intention ascriptions of belief passers and non-

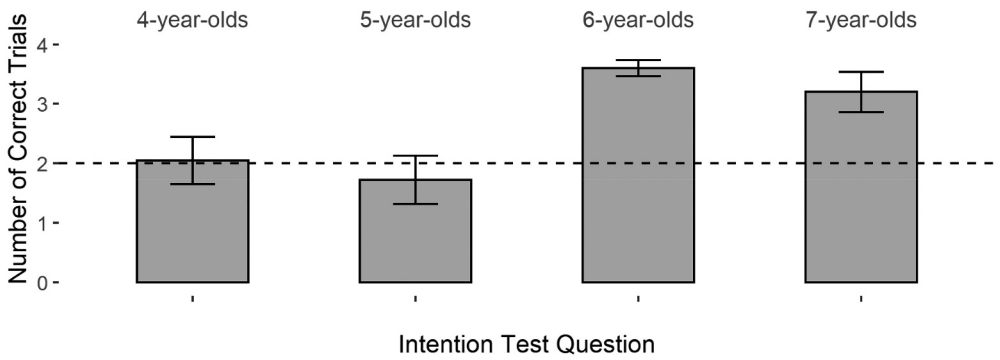


**Figure 4.** Mean number of correctly answered intention trials out of four. The dashed line depicts chance performance. Error bars depict ± 1 standard error.

**Table 4.** Contingencies age x performance intention test question.

| | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 4-year-olds (*n*= 21) | 8 (38%) | 1 (5%) | 1 (5%) | 4 (19%) | 7 (33%) |
| 5-year-olds (*n*= 18) | 8 (44%) | 0 (0%) | 3 (17%) | 3 (17%) | 4 (22%) |
| 6-year-olds (*n*= 20) | 0 (0%) | 0 (0%) | 1 (5%) | 6 (30%) | 13 (65%) |
| 7-year-olds (*n*= 20) | 3 (15%) | 0 (0%) | 2 (10%) | 0 (0%) | 15 (75%) |

Depicted is the number of children in each age group who succeeded on the according number of intention test question trials. Proportions in relation to the overall number children per age group are shown in brackets.

passers. To test for the impact of verbal intelligence, we conducted multiple regressions. Figure 4 depicts the mean number of trials in which children gave correct answers as a function of age and test question.

Again, our data were not normally distributed ($W$= 0.67, $p$< .001). Accordingly, we conducted a 4 (Age) x 2 (Scenario) ANOVA with number of correct intention trials as dependent variable on aligned rank transformed data. As before, we included all interaction and main effects. This analysis yielded a main effect for age ($F(3, 75) = 8.039$, $p$< .001, $\eta^2$ = .194). There were no other significant effects (all $F$s <1.44, all $p$s > .237; see Supplementary Material, Study 2, for details).

We tested each age group's performance on the intention test question against chance via one-sample Wilcoxon signed rank tests. 4- and 5-year-olds' performance did not exceed chance performance (all $V$s ≤44, all $p$s>.540). In contrast, 6- and 7-year-olds performed significantly above chance (all $V$s≥142.5, all $p$s<.005, all $rs$>.63). Likewise, contingencies show that most 4- and 5-year-olds continuously failed all trials while most 6- and 7-year-olds solved all trials (see Table 4).

Next, we compared performance on the intention test question between belief passers ($N$= 41) and belief non-passers ($N$= 38). Belief passers ($M$= 3.27, $SD$ = 1.32) performed significantly more proficiently than non-passers ($M$= 2.00, $SD$ = 1.72;

$W$= 1105, $p$< .001).[5] Note however, that these findings may be somewhat difficult to interpret as the reminder in the scaffolded intention task was, in fact, a belief question ("Where does the protagonist believe that A is?"). Given that children received feedback on their answers to this question and that the false believe tasks were administered after the intention tasks (and thus after children had already received four trials of feedback on the reminder) their answers to the false belief task might be difficult to interpret due to potential learning effects.

Regarding the impact of verbal intelligence, we found that children's performance on the intention test question were related ($b$= 0.154, $t$= 3.262, $p$= .002). However, when we controlled for age by adding it as a second predictor, there was no relation between verbal intelligence and intention ascriptions ($b$= 0.064, $t$= 0.933, $p$= .354; see Supplementary Material, Study 2, for more details).

### *Discussion*

Study 2 focused on our third question (under what conditions do children display an appreciation of the aspectuality of intentions?) but also speaks to the other questions. In Study 2, we radically reduced tasks demands by scaffolding children through the required inferential chains. Now, even 6-year-olds performed proficiently in the intention ascription task.

This brings us back to the first question concerning the age of onset. This relatively early age of onset contrasts with children's low performance in the spontaneous format of Study 1. It seems that, indeed, the demands of the spontaneous format did obscure children's genuine competence; and that a basic form of appreciation of the aspectuality of intentions has emerged by the age of six. Regarding our second question, the results of Study 2 converge with those of Studies 1a and b: An understanding of mis-representations appears to be necessary but not sufficient for appreciating the aspectuality of intentions.

## General discussion

### *Summary of main findings*

The present studies addressed three questions. First, what is the age of onset of children's appreciation of the aspectuality of intentions based on an agent's mis-representation? We found that only by the age of eight children spontaneously considered the agent's mis-representation in their intention ascription (Study 1). However, it appears that in these spontaneous ascriptions children's genuine competency was masked by extraneous performance factors. When we reduced these factors in Study 2, we found an age of onset around age six. The second question addressed the developmental trajectory. How is the development of the appreciation of aspectuality of intentions related to children's understanding of mis-representation in general? Study 1 found that while understanding mis-representation was necessary it was not sufficient. Following up on this, the third question was what additional capacities and conditions are necessary for children to show an appreciation of the aspectuality of intentions. Neither linguistic nor domain-general cognitive capacities explained the developmental

[5]A similar pattern emerged when we determined children's belief understanding based on their answers to the reminding question ($W$= 544, $p$= .015).

trajectory (Study 1). Only inferential complexity had a substantial impact on children's performance. When we guided children step-by-step through the inferential chain required to solve the test, 6-year-olds mastered the task proficiently.

### Understanding aspectuality as a form of advanced theory of mind

These findings may seem surprising given children's developing Theory of Mind competence around age four (or even earlier) (Wellman, Cross, & Watson, 2001). But in fact, they do converge with results from many other studies in highlighting a more protracted development of complex forms of theory of mind than suggested by an overly narrow focus on false belief tasks. Similar patterns can be found in studies on ascribing complex emotions and higher-order mental states or appreciating the interpretive nature of representations (Chandler & Lalonde, 1996; Harris et al., 1989; Liddle & Nettle, 2006; Osterhaus, Koerber, & Sodian, 2016; Perner & Wimmer, 1985). These studies, just like the present one, point toward a protracted developmental trajectory of advanced theory of mind that builds on, but goes beyond basic meta-representational theory of mind (such that the latter is necessary but not sufficient for the former).

But in what ways? What are the additional ingredients required to transform basic theory of mind into the advanced theory of mind of understanding the complex aspectuality of intentions? Currently, we do not know. Study 1 remained inconclusive and found no evidence for a role of linguistic or domain-general capacities – as measured here. Still, it is highly plausible that some form of complex domain-general and/or linguistic capacities are crucial and that Study 1 simply failed to tap them in the right kinds of ways.[6] In broader theoretical perspective, plausible candidate capacities include the mastery of "relational complexity" (Halford et al., 1998), "cognitive complexity" (Frye, David Zelazo, & Burack, 1998) or general "recursive" capacities (Hauser, Chomsky, & Fitch, 2002). Future research needs to operationalize these rather abstractly described capacities and test for their role in the ontogenetic progression from basic to advanced theory of mind.

### Competence versus performance

Still, before we interpret the present findings as indicating the relatively late emergence of a form of advanced theory of mind, one fundamental caveat needs to be discussed: Do the results of the present tasks really indicate a lack of competence (to understand the aspectuality of intentions) in children younger than age 6 or even later? Or alternatively, may children's actual competence have been masked by performance factors in these specific tasks? Indeed, Study 2 speaks in favor of the latter. Scaffolding children through the task enhanced performance of 6- and 7-year-olds. We thus cannot rule out that competence might already be present in even younger children. It might have simply been obscured by performance factors that go beyond those reduced in our guided format. One potential linguistic performance factor concerns the way children read the test question. Our test question requires the participant to apply a so-called *de dicto* (about what is said) reading

[6]Remember, none of the age groups 3- to 7-year-olds ascribed intentions proficiently. Accordingly, it is possible that the necessary extent of linguistic and domain-general capacities exceeds the scope of our sample.

(see Jacob, 2019; McKay & Nelson, 2014; Quine, 1956). Here, the truth of an intention report depends on whether the agent would report her intention in that particular way. This implies that the substitution of co-referential terms (*Walt*/*Heisenberg*) can affect the truth-value of the intention report. Take the intention report "Hank intends to convey secret information to Heisenberg." Hank would never have reported the intention in that way. Thus, on the *de dicto* level this report is plainly false. Yet, another way to approach the test question is to apply a *de re* (about the thing) reading. Here, the truth of the intention report does not depend on Hank's perspective and allows the substitution of co-referential terms. Thus, in our task the action is unintentional under the mis-represented description on a *de dicto* level. In contrast, it is intentional on a *de re* level irrespective of the description (Hank intended to do what was in fact the reporting of secrets to Heisenberg). Of course, we assumed that the most intuitive approach to our task would be the *de dicto* reading. And indeed, the results from adults show that for them, the *de dicto* reading is natural and obvious. That it is not equally obvious for children may mean that they do not understand the *de dicto* reading in principle. But alternatively, it may mean that they understand both *de re* and *de dicto* readings but have different thresholds for when they find one rather than the other obvious. Perhaps the *de dicto* reading in the present tasks was simply not sufficiently salient, relevant and obvious to them?

Whether or not Hank intended to tell secret information to Heisenberg is without doubt highly salient and relevant (it will change Hank's life, in fact). The same is true for many decisions. Should you be angry with your neighbor who during your vacation killed your orchid, because she mis-took it for a plastic replica? Should a child be angry at her grandmother because she gave her a pink note pad for Christmas which she thought was the desired "tablet"? Examples like these show how significant the consideration of aspectuality of intentions often is. It even extends to issues of culpability: Should a judge convict a vendor whose action of selling alcohol to minors is against the law under the actual description, but not under the mis-represented description she held, because the minors showed her a forged ID. In contrast, whether or not the hedgehog intended to take the pen in our task is by far not of comparable real-life relevance. Now, the rationale behind choosing the present scenarios was to test for an understanding of the aspectuality of intentions in comparable vignettes and formats that conform to standard procedures. However, it is possible that in these scenarios it did not become clear to the children that they were required to judge the intentionality from the agent's perspective. And as our aim is not to find when children develop an adult-like approach to aspectuality that comprises irrelevant cases, but when they develop an understanding of intentions in general. Accordingly, before we categorize understanding the aspectuality of intentions as part of protracted Theory of Mind development, future research needs to address this alternative explanation. This requires a task that clearly and conclusively asks for a *de dicto* reading. One such case would be child-friendly versions of the Walt/Heisenberg-type in which the aspectuality of intentionality is practically and morally highly obvious, salient and relevant.

## Conclusion

Taken together, the present studies found that children have substantial difficulties appreciating that actions are not intentional under mis-represented descriptions. Such an appreciation of the aspectuality of intentions appears to develop late (not before six) and to go substantially beyond the ability to ascribe mis-representations in general. Even though

ascribing mis-representations seems to be necessary, it alone is not sufficient. All of these are features that the appreciation of the aspectuality of intentions shares with other capacities that belong to protracted theory of mind development. Yet, future research needs to follow up on this. First, to check whether we measured children's genuine competence (or whether their true competence was masked by performance factors of the specific tasks). And second, in case the picture of a necessary but not sufficient developmental trajectory persists, to identify the crucial additional capacities that are necessary in the progression from basic to advanced Theory of Mind.

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## Data availability

Data will be made available on request.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

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## References

Anscombe, G. E. M. (1957). *Intention*. Oxford, United Kingdom: Basil Blackwell.

Astington, J. W. (2001). The paradox of intention: Assessing children's metarepresentational understanding. *Intentions and Intentionality: Foundations of Social Cognition*, 6 , 85–103.

Behne, T., Carpenter, M., Call, J., & Tomasello, M. (2005). Unwilling versus unable: Infants' understanding of intentional action. *Developmental Psychology*, *41*(2), 328. doi:10.1037/0012-1649.41.2.328

Chandler, M. J., & Lalonde, C. (1996). InSameroff, A. J, and Haith , M. M (Eds.),Shifting to an interpretive theory of mind: 5-to 7-year-olds' changing conceptions of mental life. *The Five to Seven Year Shift: The Age of Reason and Responsibility*, (pp.111–139). University of Chicago Press.

Flavell, J. H., Everett, B. A., Croft, K., & Flavell, E. R. (1981). Young children's knowledge about visual perception: Further evidence for the Level 1–Level 2 distinction. *Developmental Psychology*, *17*(1), 1. doi:10.1037/0012-1649.17.1.99

Flavell, J. H., Green, F. L., Flavell, E. R., Watson, M. W., & Campione, J. C. (1986). Development of knowledge about the appearance-reality distinction. *Monographs of the Society for Research in Child Development*, *51*(1), i–87. doi:10.2307/1165866

Flavell, J. H., Shipstead, S. G., & Croft, K. (1978). Young children's knowledge about visual perception: Hiding objects from others. *Child Development*, *49*(4), 1208. doi:10.2307/1128761

Frye, D., David Zelazo, P., & Burack, J. A. (1998). Cognitive complexity and control: I. Theory of mind in typical and atypical development. *Current Directions in Psychological Science*, *7*(4), 116–121.

Gergely, G., Bekkering, H., & Király, I. (2002). Rational imitation in preverbal infants. *Nature*, *415*, 6873. doi:10.1038/415755a

Hadwin, J., & Perner, J. (1991). Pleased and surprised: Children's cognitive theory of emotion. *British Journal of Developmental Psychology*, *9*(2), 2. doi:10.1111/j.2044-835X.1991.tb00872.x

Halford, G. S., Wilson, W. H., & Phillips, S. (1998). Processing capacity defined by relational complexity: Implications for comparative, developmental, and cognitive psychology. *Behavioral and Brain Sciences*, *21*(6), 803–831. doi:10.1017/S0140525X98001769

Harris, P. L., Johnson, C. N., Hutton, D., Andrews, G., & Cooke, T. (1989). Young children's theory of mind and emotion. *Cognition & Emotion*, *3*, 4. doi:10.1080/02699938908412713

Hauser, M. D., Chomsky, N., & Fitch, W. T. (2002). The faculty of language: What is it, who has it, and how did it evolve?. *Science*, *298*(5598), 1569–1579. doi:10.1126/science.298.5598.1569

Jacob, P. (2019). Challenging the two-systems model of mindreading. *Knowing Other Minds*, 79.

Kamawar, D., & Olson, D. R. (2011). Thinking about representations: The case of opaque contexts. *Journal of Experimental Child Psychology*, *108*, 4. doi:10.1016/j.jecp.2010.10.005

Kay, M. (2020, March 19). *Effect Sizes with ART*. The Comprehensive R Archive Network. Retrieved from May 26, 2020, https://cran.r-project.org/web/packages/ARTool/vignettes/art-effect-size.html

Kay, M., & Wobbrock, J. O. (2020, March 20). *ARTool: Aligned rank transform*. The Comprehensive R Archive Network. Retrieved from May 26, 2020, https://cran.r-project.org/web/packages/ARTool/

Lang, B., & Perner, J. (2002). Understanding of intention and false belief and the development of selF-control. *British Journal of Developmental Psychology*, *20*(1), 67–76. doi:10.1348/026151002166325

Liddle, B., & Nettle, D. (2006). Higher-order theory of mind and social competence in school-age children. *Journal of Cultural and Evolutionary Psychology*, *4*(34), 231–244. doi:10.1556/JCEP.4.2006.3/4.3

Liu, D., Gelman, S. A., & Wellman, H. M. (2007). Components of young children's trait understanding: Behavior to trait inferences and trait to behavior predictions. *Child Development*, *78*(5), 1543–1558. doi:10.1111/j.1467-8624.2007.01082.x

McKay, T., & Nelson, M. (2014). Propositional attitude reports. In E. N. Zalta Ed., *The Stanford encyclopedia of philosophy* (Spring 2014 ed.). Retrieved from http://www.plato.stanford.edu/archives/spr2014/entries/prop-attitude-reports/

Melchers, P., & Preuß, U. (2009). Kaufman assessment battery for children 8. unveränderte auflage. *Frankfurt/Main: Pearson Assessment*.

Meltzoff, A. N. (1995). Understanding the intentions of others: Re-enactment of intended acts by 18-month-old children. *Developmental Psychology*, *31*(5), 838. doi:10.1037/0012-1649.31.5.838

Michel, E., & Roebers, C. M. (2008). Children in regular and special needs classes: Cognitive and non-cognitive aspects. *Swiss Journal of Psychology/Schweizerische Zeitschrift Für Psychologie/Revue Suisse de Psychologie*, *67*(4), 249. doi:10.1024/1421-0185.67.4.249

Osterhaus, C., Koerber, S., & Sodian, B. (2016). Scaling of advanced theory-of-mind tasks. *Child Development*, *87*(6), 1971–1991. doi:10.1111/cdev.12566

Perner, J., & Howes, D. (1992). " He thinks he knows": And more developmental evidence against the simulation (role taking) theory. *Mind & Language*. doi:10.1111/j.1468-0017.1992.tb00197.x

Perner, J., & Wimmer, H. (1985). "John thinks that Mary thinks that . . . " attribution of second-order beliefs by 5-to 10-year-old children. *Journal of Experimental Child Psychology*, *39*(3), 437–471.

Ponitz, C. E. C., McClelland, M. M., Jewkes, A. M., Connor, C. M., Farris, C. L., & Morrison, F. J. (2008). Touch your toes! Developing a direct measure of behavioral regulation in early childhood. *Early Childhood Research Quarterly*, *23*(2), 141–158. doi:10.1016/j.ecresq.2007.01.004

Proft, M., & Rakoczy, H. (2019). The ontogeny of intent based normative judgments. *Developmental Science*, *22*(2), e12728. doi:10.1111/desc.12728

Proft, M., Schünemann, B., & Rakoczy, H. (2019). Journal of experimental child psychology. *Children's Understanding of the Aspectuality of Intentions*, *181*. doi:10.1016/j.jecp.2018.12.001

Quine, W. V. (1956). Quantifiers and propositional attitudes. *The Journal of Philosophy*, *53*(5), 177–187. doi:10.2307/2022451

Rakoczy, H., Bergfeld, D., Schwarz, I., & Fizke, E. (2015). Explicit theory of mind is even more unified than previously assumed: Belief ascription and understanding aspectuality emerge together in development. *Child Development*, *86*, 2. doi:10.1111/cdev.12311

Schult, C. A. (2002). Children's understanding of the distinction between intentions and desires. *Child Development*, *73*(6), 6. doi:10.1111/1467-8624.t01-1-00502

Searle, J. R., & Willis, S. (1983). *Intentionality: An essay in the philosophy of mind*. United Kingdom: Cambridge university press.

Shultz, T. R., & Wells, D. (1985). Judging the intentionality of action-outcomes. *Developmental Psychology*, *21*(1), 83. doi:10.1037/0012-1649.21.1.83

Sullivan, K., Zaitchik, D., & Tager-Flusberg, H. (1994). Preschoolers can attribute second-order beliefs. *Developmental Psychology*, *30*(3), 395. doi:10.1037/0012-1649.30.3.395

Wellman, H. M., Cross, D., & Watson, J. (2001). Meta-analysis of theory-of-mind development: The truth about false belief. *Child Development*, *72*(3), 655–684. doi:10.1111/1467-8624.00304

Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition*, *13*(1), 1. doi:10.1016/0010-0277(83)90004-5

Wobbrock, J. O., Findlater, L., Gergle, D., & Higgins, J. J. (2011, May). The aligned rank transform for nonparametric factorial analyses using only anova procedures. In *Proceedings of the SIGCHI conference on human factors in computing systems*. Vancouver BC Canada. (pp. 143–146). doi:10.1145/1978942.1978963

Woodward, A. L. (1998). Infants selectively encode the goal object of an actor's reach. *Cognition*, *69*(1), 1–34. doi:10.1016/S0010-0277(98)00058-4