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Children's understanding of the aspectuality of intentions

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ABSTRACT

When children come to grasp the concept of intention is a central question in theory of mind research. Existing studies, however, present a puzzling picture. On the one hand, infants distinguish between intentional and accidental actions. On the other hand, previous work suggests that until 8 years of age children do not yet understand an essential property of intentions—their aspectuality. Intentions are aspectual in the sense that they refer to objects and actions only under specific aspects. For example, Oedipus married Jocasta without knowing that she was his mother. Thus, he intentionally married Jocasta but did not intentionally marry his mother. However, the negative findings from these studies may indicate performance limitations rather than competence limitations. The rationale of the current set of studies, therefore, was to test children's understanding of the aspectuality of intentions in a simplified, cognitively less demanding design. The participants, 5- and 6-year-olds (Study 1) and 4-year-olds (Study 2), were involved in simple games where they (or another agent) intentionally acted on objects that had an obvious first identity and a hidden second identity. Children either did or did not know about the toy's second identity at the moment of acting. After their actions, children were asked about their intentions regarding the toys' different identities. Results revealed that the 5- and 6-year-olds, but not the 4-year-olds, systematically considered how they (or another agent) represented the objects when making intentionality judgments. Thus, an understanding of aspectual intentions seems to develop at around the late preschool years—much earlier than previously assumed.

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Introduction

In everyday folk psychology, one of the most basic and important distinctions we make is between actions that agents perform intentionally and mere behavior that happens to them. In developmental theory of mind research, therefore, one of the fundamental questions is how children develop a grasp of intentions. Much research has addressed this question, but the empirical picture that emerges so far is complex and still somewhat inconsistent.

On the one hand, infancy research suggests that even 9-month-olds distinguish between intentional actions and accidental mistakes (e.g., Behne, Carpenter, Call, & Tomasello, 2005; Carpenter, Akhtar, & Tomasello, 1998; Meltzoff, 1995). On the other hand, research with more complex verbal scenarios suggests that before 5 years of age children fail to understand some of the essential and fundamental aspects of intentions. These aspects include the logical differences between intentions and desires and other *pro-attitudes* or the fact that one and the same physical behavior can be brought about by different intentions and, thus, can constitute different types of actions (Astington, 1991; Baird & Moses, 2001; Phillips, Baron-Cohen, & Rutter, 1998; Schult, 2002). Thus, these two sets of apparently diverging findings raise a *paradox of intentions* (Astington, 2001); depending on the task, children seem to acquire a concept of intention either during the first year of life or several years later. This paradox, however, can be resolved in the following way. From infancy, children already operate with a generic teleological pro-attitude concept pertaining to the goals individuals pursue (Gergely & Csibra, 2003; Perner & Roessler, 2010). Pro-attitudes in this sense are attitudes an agent has toward situations or actions of a certain kind (Davidson, 1963). This concept does not yet allow for any distinctions between different kinds of pro-attitudes (e.g., desires, values, goals, intentions), but it enables children to predict and explain goal-directed intentional behavior and to distinguish between intended and unintended actions. However, for a fully-fledged understanding of intentions as causally relevant mental states that include action plans and commit agents to future courses of action (Bratman, 1987) and, thus, differ from desires in a number of crucial ways, a *metarepresentational* conception of mental states is required (Astington, 2001; Gergely & Csibra, 2003; Perner & Roessler, 2010; Perner, 1991). And such a framework conception of metarepresentation is acquired only at around 4 or 5 years of age (Perner & Roessler, 2012).

But do children at 4 or 5 years of age then operate with a fully fledged adult concept of intention? Another recent line of research casts doubt on this. This research has investigated when children come to understand another essential logical property of intentions—their aspectuality. Intentions (and other mental states) are aspectual in the sense that they refer to objects or states of affairs under only some specific aspects or descriptions and not under others (e.g., Searle, 1983; McKay & Nelson, 2014). To illustrate, consider the story of Oedipus. According to Greek mythology, Oedipus married Jocasta while unaware that she was his mother. So whereas in some sense he married both Jocasta and his mother (they are identical after all), the situation is more complex concerning his intentional actions; he married Jocasta intentionally only under the description "Jocasta" and not under the description "my mother." Thus, "Oedipus intentionally married Jocasta" is true, whereas "Oedipus intentionally married his mother" is false (even though "Jocasta" and "Oedipus' mother" refer to the same person).

So far, only one study has investigated the development of children's understanding of the aspectuality of intentions in this sense (Kamawar & Olson, 2011). In this study, children were confronted with short illustrated vignettes that were structurally analogous to the Oedipus story. Mark witnessed a police officer drop a set of keys and decided to give the keys back to him. The police officer was in fact Cathy's dad. This second piece of information was revealed only to the child but was unknown to Mark. The crucial intention test questions were then (a) whether Mark intended to give the keys to the police officer (yes) and (b) whether Mark intended to give the keys to Cathy's dad (no). Results revealed that only children from 8 years of age onward solved this task by answering the second question with "no," whereas 6-year-olds answered at chance and 4-year-olds even tended to affirm.

Thus, this looks like a second "paradox of intention." On the one hand, 4- and 5-year-olds operate with a fully fledged metarepresentational concept of intentions and propositional attitudes more generally, as suggested by the research reviewed above. On the other hand, research on children's understanding of the aspectuality of intentions suggests that children do not grasp fundamental and essential properties of intentions and, thus, cannot be said to operate with a fully fledged concept of intention before 8 years of age.

One way to respond to this apparent paradox would be to simply reject it. There is no paradox, one could argue. Rather, the most stringent tests—those involving the aspectuality of intentions—clearly show that children just do not reason with fully-fledged concepts of intentions before 8 years of age (which is not to deny that they operate with some mental state concepts before, of course, but these would be logically less complex precursor concepts). This conclusion fits with the more general picture that emerges from older studies on children's understanding of aspectuality (Apperly & Robinson, 1998, 2003; Kamawar & Olson, 1999; Russell, 1987; Sprung, Perner, & Mitchell, 2007). These studies have mainly focused on children's developing understanding of the aspectuality of beliefs. To illustrate, imagine the following situation. Heinz knows that there is an eraser in Box A and a die in Box B. The die is also an eraser. Heinz, however, does not know this. So, when he is looking for an eraser, where will Heinz look? To arrive at the correct answer (''Box A"), one needs to take into account the aspectuality of Heinz's beliefs. Although there are erasers in both boxes, Heinz represents only the object in Box A as ''eraser." When presented with such scenarios, children considered only the aspectuality of beliefs and, thus, gave correct answers from 6 or 7 years of age onward (Apperly & Robinson, 1998; Sprung et al., 2007). Taken together, this line of research can be (and has been) interpreted along the following lines. Because aspectuality is an essential element of propositional attitudes, one cannot be said to operate with a fully-fledged concept of such states without grasping their aspectuality. These studies, however, show that children do not grasp aspectuality before age 7 and, thus, cannot operate with fully fledged concepts of propositional attitudes at all.

In contrast to such a drastic competence deficit response, another way to resolve the second paradox of intention would be in terms of performance limitations; that is, children fail aspectuality tasks because of performance deficits rather than competence deficits such as working memory and verbal demands or lack of involvement and relevance. This conclusion fits with more recent work in the area of belief reasoning (Rakoczy, Bergfeld, Schwarz, & Fizke, 2015). In one study, children were presented with a version of the Heinz scenario described above. This new version was simplified in terms of complexity, working memory demands and the like and involved only one object. A dual-identity object that was both a pen and a rattle was put into Box 1 in the presence of Heinz under its pen aspect (one could see that it is a pen but could find out that it is a rattle only by shaking and listening). In the second step, not witnessed by Heinz, the object was taken out of the box and its other aspect (rattle) was revealed, and it was put back into Box 1. In the final step, visible to Heinz, the object was moved under its rattle aspect (in such a way that one could not see the object but could hear that it is a rattle) from Box 1 to Box 2. The crucial test question was ''Where will Heinz look for the pen?" To arrive at the correct answer (''Box 1"), again one needs to take into account the aspectuality of Heinz's belief. Although he saw the rattle being moved to Box 2, and the rattle was the pen, he represented the transfer of the object only under the description ''rattle" and, thus, still believed that the pen was in Box 1. Results revealed that with this simplified procedure, now even 4-year-olds answered correctly. Performance in such cognitively less demanding aspectuality tasks was also highly correlated with performance in standard false belief tasks. This pattern indicates that children seem to acquire a unified understanding of beliefs, including both their aspectual and non-aspectual elements, at the same time (see also Oktay-Gür & Rakoczy, 2017; Rakoczy, 2017).

Against this background, similar questions arise with regard to children's understanding of the aspectuality of intentions. Could their understanding have been masked by external task demands? If so, what may have been the limiting performance factors in previous studies (Kamawar & Olson, 2011)? A closer look at the stimuli suggests at least three potential kinds of such performance factors. First, the vignettes were presented verbally (accompanied by illustrations). This mainly verbal format presumably not only posed high linguistic task demands (i.e., understanding the verbal information) but also came along with excessive working memory demands of processing the linguistic information. Because both linguistic ability and working memory capacities increase only gradually throughout childhood (Gathercole, Pickering, Ambridge, & Wearing, 2004; Riley, 1987), it is likely that younger children fail such demanding tasks only because their linguistic and working memory capacities are exceeded. Second, children's engagement with the tasks might have been low given that their role was restricted to third-party observation. For instance, it has been found that enacting, in contrast to solely observing, enhances both children's and adults' performance on memory tasks (Cohen, 1981; Saltz & Donnenwerth-Nolan, 1981). Third, the stories may have lacked sufficient relevance for children to care about the correct answer. Whether or not Mark intentionally gave the keys to the police officer seems to make little difference to anything that matters. In contrast, compare this, as an illustration, with the story of Oedipus, in which whether or not Oedipus intentionally married his mother has obvious relevance (e.g., legal, moral, aesthetic). In line with this, performance on different cognitive tasks has been shown to increase when relevance establishing consequences were applied (Firestone & Douglas, 1975; Witte & Grossman, 1971).

Thus, it may well be that due to these methodological factors, previous work has underestimated children's competence of ascribing aspectual intentions. And this may be the key to resolving the second puzzle of intention: that is, once tested with suitably modified tasks, even preschoolers may understand the aspectuality of intentions. Thus, the rationale of the current set of studies was to develop such simplified tasks that test children's appreciation of the aspectual nature of intentions. In addressing the three main issues raised above, we designed a task with reduced working memory demands, first-person involvement, and increased relevance. In this task, children played two consecutive games with a puppet: a farm game and a sticker game. Both games were played with the same toy animals. Each animal had one obvious identity (being a cow, horse, etc. in the farm game) and a hidden second identity (its role in the sticker game). After both games were played, we asked children about their own and the puppet's knowledge and intentions with regard to each animal's hidden second identity. In a first step, we tested 5- and 6-year-old children and adults. We found that overall children were as competent as adults in understanding the aspectuality of intentions. Even the 5-year-olds correctly considered the agent's knowledge about the different aspects of the animals when asked about the intentional structure of the action. In a second step, we then explored the emergence of this ability by testing 4-year-olds in a structurally analogous but slightly simplified task. In contrast to the older children's performance, the performance of the younger children was at chance level, suggesting that the ability to ascribe aspectual intentions emerges at around 5 years of age.

Study 1

The objective of the first study was to test 5- and 6-year-olds' ability to ascribe aspectual intentions in an interactive task. We focused on 5- and 6-year-olds because previous research has shown that from age 5 onward children generally show a robust understanding of most fundamental aspects of intentions. If the children in our study now also perform competently in our suitably simplified task, then there is no second paradox of intention after all given that the understanding of the aspectuality of intentions seems to align with the understanding of most other essential properties of intentions.

This was implemented in the following ways. In the experimental condition, 5- and 6-year-olds played a farm game with a puppet in which the players could choose animals to build their farms. After their choice, the experimenter told them that the animals had an invisible second identity pertaining to their role in another sticker collection game. In this game, the animals were identified as either "Blickets" or "Zickets" with the help of a "Blicket–Zicket detector." If an animal turned out to be a Blicket, this led to the loss of one sticker (negative valence). If it turned out to be a Zicket, there was no change in the amount of stickers (neutral valence). After discovering the second identity, children were asked the *epistemic test question* of whether they knew about the second identity before (correct answer: "no") and the critical *intention test question* of whether they intentionally[1] picked the animal under the description of the second identity (correct answer: "no").

A second group of children in the control condition ran through the same procedure except for one critical difference. These children were informed about the second game, and thus the second identities of the animals, before picking them for their farms. Thus, the control condition directly matched

[1] 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).

the experimental condition concerning the objects and actions involved: the animals had the same dual identities, and the performed actions—picking the animals—were identical. The only difference was that the agent knew about the dual identities. Yet, this difference changed the logic of the test questions. For the epistemic question, the correct answer now was clearly "yes": the agent knew about the second identity. For the intention question, the correct answer was less clear; however, "yes" and "unclear" seem to be the most valid answers. Importantly, the correct answer is not as clearly "no" as in the experimental condition. The reason for this ambiguity lies in the difference between intended means and foreseen side effects: just because the agent knew that the animal she or he picked (e.g., the cow) was also a Zicket does not necessarily mean that the agent intended to pick a Zicket. Although the agent might have taken the cow because it was a Zicket (intended means), it is equally possible that she or he only intended to pick the cow while knowing but not caring about the fact that it was a Zicket (foreseen side effect). Importantly, from the agent's knowledge and her or his action alone, we cannot tell and thus the correct answer to the crucial intention test question is unclear (see Table 1 for an outline of the experimental logic of the study).

In addition to the main task, children's first- and second-order false belief understanding was assessed. In parallel with the interactive child version, we ran an adult control group with a paper-and-pencil version of the task. We included the adult population to compare children's performance against the "mature" adult intuition.

Method

Participants

In total, 42 5-year-olds (range = 60–71 months, *M* = 65.11 months, *SD* = 3.28; 26 male) and 41 6-year-olds (range = 72–83 months, *M* = 78.20 months, *SD* = 3.67; 13 male) were recruited from local kindergartens and from a databank of children whose parents had previously given consent to experimental participation. Furthermore, 40 adults (range = 20–33 years, *M* = 24.03 years, *SD* = 3.16; 14 male) participated after being recruited on the campus of Göttingen University. Two 5-year-old male participants needed to be excluded from analysis because of language problems. Three male adults were excluded because they gave invalid answers to the test questions indicating that these participants did not take the questionnaire seriously (e.g., "No, she thought the dog was the man's best friend"; "Cows are always Blickets").

Design and procedure

A 3 (Age Group: 5-year-olds, 6-year-olds or adults) × 2 (Valence: neutral or negative) × 2 (Condition: experimental or control) × 2 (Test Question: epistemic or intention) mixed design was conducted with valence and test question as within-participants factors. Participants were randomly assigned to either the experimental or control condition. For the child subsamples, there was a further within-participants factor of perspective (first-person or third-person). This factor could not be implemented in the adult version because adults received a paper-and-pencil task without any game elements and, thus, without any first-person involvement (see below). Children received eight trials in

Table 1
Basic experimental logic of the two conditions.

	Experimental condition	Control condition
Objects	Dual identity objects with identities X and Y	
Action	Action A on identity X	
Time dual identity is revealed to the agent	After action A	Before action A
Agent's knowledge about objects when performing A	Objects as X	Objects as X and objects as Y
Epistemic test question	Did you (the puppet) know X = Y?	
	Correct answer: no	Correct answer: yes
Intention test question	Did you (the puppet) intentionally perform action A on Y?	
	Correct answer: no	Correct answer: unclear

counterbalanced order, two per combination of valence and perspective. Adults received only four trials (limited to the third-person perspective). For each trial, participants answered both test questions.

Experimental condition. The experiment consisted of two parts. In the first part, children together with a puppet each built their own farm. For these farms, they needed to choose four wooden farm animals out of a bowl and put them on placemats, each showing four enclosures in which the animals were to be placed. The second part consisted of the Blicket–Zicket game, a sticker collection game during which the animals' second identities were revealed. Corresponding to the categories of the factor valence, animals that were Blickets induced the loss of one sticker (negative valence) and those that were Zickets did not change the number of stickers (neutral valence). Importantly, the existence of the second game was unknown to children and the puppet during the first part of the procedure.

In the Blicket–Zicket game, children and the puppet were told that they start with one smiley sticker per animal but that the stickers could be lost and only the remaining ones would be equally distributed between both of them. The number of stickers was illustrated on a tablet showing the respective number of smileys. After that, the Blicket–Zicket detector was introduced—a big yellow box whose function was to identify the animals' second identities. When an animal whose second identity was a Blicket was put on the detector, a sad sound occurred and one smiley on the tablet disappeared. Correspondingly, when a Zicket was put on the detector, a happy sound occurred and the number of smileys remained unchanged. After the introduction of the game, children were asked check questions about the function of Blickets and Zickets ("What do Blickets do? What do Zickets do?"; wrong answers were corrected). The loudspeaker and the tablet were secretly operated by the experimenter in a way that both the puppet and the child had two Blickets and two Zickets on their farms.

One after the other, all eight animals were put on the detector. After each animal, the experimenter said, "You intentionally chose a [animal] for your farm. The [animal] is also a Blicket/Zicket." After this, the two test questions were administered:

- *Epistemic question:* Did you (the puppet) know that the [animal] was also a Blicket/Zicket?
- *Intention question:* Did you (the puppet) intentionally choose a Blicket/Zicket?[2]

When the puppet's animals were looked at, the puppet left the room to eliminate the possibility that children consulted the puppet's expression. Finally, children and the puppet received the remaining stickers and children distributed them between themselves and the puppet.

Control condition. The procedure differed from the experimental condition in only one respect. Children and the puppet were informed about the second game, and thus the animals' second identities, before choosing the animals for their farm. In addition, all Blicket animals were marked with a blue sticker to facilitate children's recognition of the Blickets versus Zickets. Because children knew about the second identities before choosing their animals, they could now freely choose the proportion of neutral Zickets and negative Blickets. As a consequence, some children chose three Zickets ($n = 13$) or even four Zickets ($n = 14$) to reduce the number of negative Blickets on their farms (indicating a clear understanding of the game).[3] Note, however, that this behavior led to an unbalanced sample size for the first-person trials comparing the experimental and control conditions. To reduce this effect as much as possible, we coded for children's answers to only the first two Zickets. The puppet still chose two Blickets and two Zickets.

Adults. Adults completed a paper-and-pencil version of the task that was limited to the third-person perspective. Note that this limitation naturally arose from the paper-and-pencil format, which made it

[2] In contrast to the original study by Kamawar and Olson (2011), who asked for both the known first identity and unknown second identity, we decided to explicitly state that the action was intentional toward the first identity and asked only for the second identity. The main reason for this was to reduce pragmatic confusion that may occur if test questions are too trivial (see, e.g., Oktay-Gür & Rakoczy, 2017).

[3] One 5-year-old even chose three Blickets and one Zicket.

impossible to ask the adults to build their own farms and ask questions about "their" animals. Participants first read a scenario about a puppet building a farm and later playing the Blicket–Zicket game and were then asked to write down their answers to the two test questions for each animal. Crucially, just as in the child version, the puppet (and thereby the adult) either knew or did not know about the dual identities when building thefarm.

False belief understanding. Before the main experiment, children's false belief competence was assessed with a location change false belief task (Wimmer & Perner, 1983). Children observed a protagonist who first hid her toy in one of two boxes and then left the scene. In her absence, the toy was moved to the other box by a second protagonist. Control questions were asked to ensure that children knew about the toy's initial location, its current location and who had put it there. Incorrect answers were corrected. False belief competence was measured by the standard first-order question ("Where will she look for the toy?") as well as by a second-order question ("If we ask her 'Do you know where the toy is?' what will she say?") (Perner & Howes, 1992).

Results

For purposes of analysis, we coded for children's "no" answers to the two test questions and computed a "proportion of 'no' answers" score (by dividing the number of "no" answers by the overall number of answers). Fig. 1 depicts the means of these proportion scores as a function of age, condition, valence, and question.

Plan of analysis

There were three main questions of interest in our study. First, to test whether participants answered differently in the experimental condition than in the control condition, analyses of variance (ANOVAs) were conducted. Second, to test for children's specific performance in the experimental condition, planned one-sample *t* tests on participants' proportion of "no" answers against chance performance were computed. Third, we looked at the relation between answers in the main task and those in the false belief task via children's pattern of answers.

Experimental condition versus control condition

Our central research question was whether participants answered differently in the experimental condition than in the control condition. Recall that for the epistemic test question the answer "no" was clearly correct in the experimental condition and clearly incorrect in the control condition. For the intention test question, the answer "no" was also clearly correct in the experimental condition but not as clearly incorrect in the control condition. Thus, the crucial test was whether participants answered the test questions more often with "no" in the experimental condition than in the control condition.

The prima facie most straightforward implementation of this test would be an ANOVA on the complete design, that is, a 3 (Age) × 2 (Condition) × 2 (Test Question) × 2 (Valence) × 2 (Perspective) ANOVA with the proportion of "no" answers as dependent variable. However, the design was not fully crossed because the adult version was limited to the third-person perspective. In addition, the design for the two child age groups was unbalanced because not all children in the control condition chose Blickets (they knew that a Blicket would reduce their amount of stickers later in the game). As a consequence, the data from the first-person perspective could not be included in the main ANOVA.[4]

Thus, we conducted a 3 (Age: 5-year-olds, 6-year-olds, or adults) × 2 (Condition: experimental or control) × 2 (Test Question: epistemic or intention) × 2 (Valence: neutral or negative) ANOVA with the proportion of "no" answers as dependent variable. This analysis yielded a main effect of condition, $F(1, 112) = 86.45$, $p < .001$, $\eta^2_p = .44$, a main effect of valence, $F(1, 112) = 12.83$, $p = .001$, $\eta^2_p = .10$, and an

[4] Note, however, that for the sake of completeness we also ran the 2 (Age: 5-year-olds or 6-year-olds) × 2 (Condition: experimental or control) × 2 (Test Question: epistemic or intention) × 2 (Valence: neutral or negative) ×2 (Perspective: first-person or third-person) ANOVA on the reduced sample size. The general pattern of results concerning the relevant effects did not change. See Appendix B.

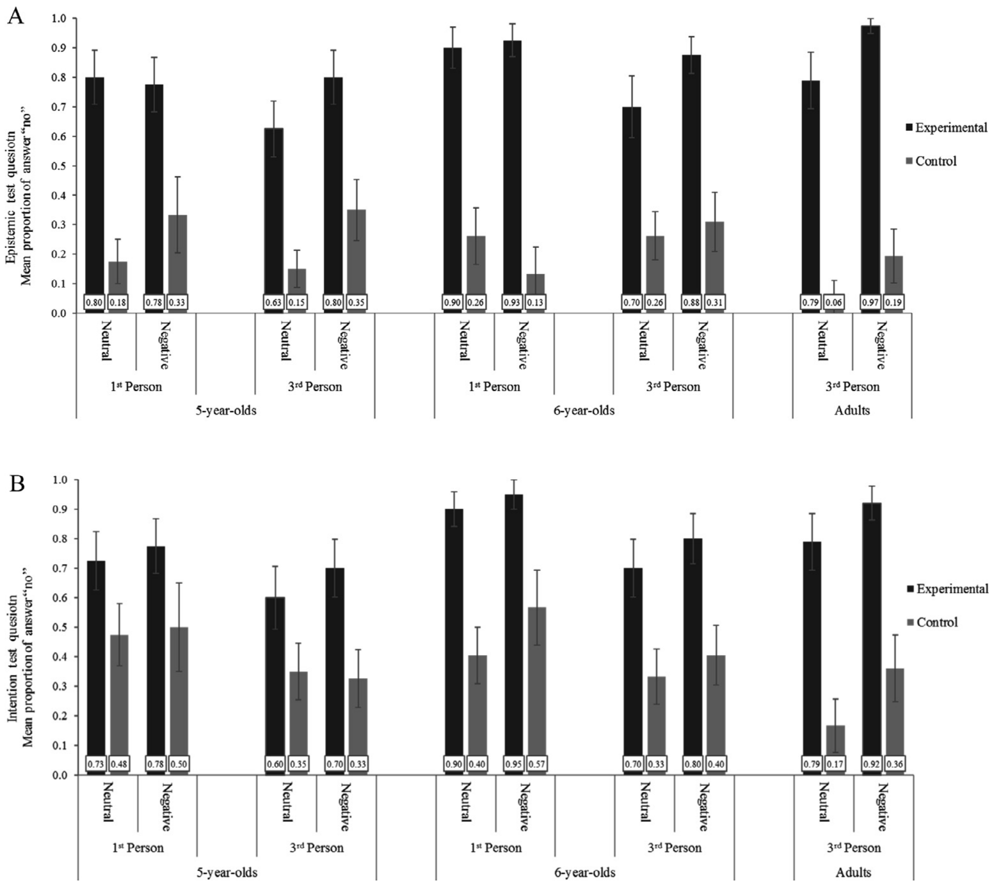

Fig. 1. Mean proportions of "no" answers to the epistemic (A) and intention (B) test questions for the experimental and control conditions in the respective age groups. Error bars display ± 1 standard error.

interaction effect between test question and condition, $F(1, 112) = 5.42$, $p = .022$, $\eta^2_p = .05$. There were no other significant effects (all Fs < 2.59, all ps > .08; see Appendix A for details). Thus, participants across age groups answered the test questions—both the epistemic and intention ones—more often with "no" in the experimental condition than in the control condition. As predicted, however, the overall difference between the experimental and control conditions was smaller for the intention test question than for the epistemic one. Furthermore, participants answered test questions with "no" more often for the negatively valenced animals than for the neutral ones.

Performance in experimental condition

We then examined the answer patterns in the experimental condition more closely. Overall, all three age groups performed significantly above chance: they correctly denied their own and the puppet's knowledge about the second identity [5-year-olds: $t(19) = 3.94$, $p = .001$, $d = 0.88$; 6-year-olds: $t(19) = 6.66$, $p < .001$, $d = 1.49$; adults: $t(18) = 7.91$, $p < .001$, $d = 1.80$] as well as the intentionality of choosing this second identity [5-year-olds: $t(19) = 2.43$, $p = .025$, $d = 0.54$; 6-year-olds: $t(19) = 7.15$, $p < .001$, $d = 1.60$; adults: $t(18) = 5.52$, $p < .001$, $d = 1.27$].

One of the guiding hypotheses concerning previous work was that it may have underestimated children's competence by asking them to make uninvolved third-person judgments in a context of little relevance. To address this hypothesis, we analyzed performance separately for all conditions as a function of age, valence, and perspective. Results revealed that all age groups performed above chance in all conditions (all $ts \geq 2.98$, all $ps < .04$) with the following crucial exceptions: The 5- and 6-year-olds' answers to both the epistemic and intention test questions regarding the *third-person neutral* perspective (puppet choosing a Zicket, all $ts \leq 2.03$, all $ps > .05$), as well as 5-year-olds' answers to the intention question regarding the *third-person negative* perspective [puppet choosing a Blicket, $t(19) = 2.03$, $p = .057$, $d = 0.93$], did not significantly differ from chance.

False belief understanding

Overall, 90% and 63% of children answered the first-order and second-order test questions of the false belief task correctly, respectively. Table 2 shows the contingency tables of children's performance on first- and second-order false belief tasks and their performance on the intention test question. No systematic covariation could be observed for either of the false belief questions.

Discussion

Study 1 investigated 5- and 6-year-olds' understanding of the aspectuality of intentions. Results revealed that under the right circumstances—with enhanced relevance and first-person involvement—even 5-year-olds correctly considered an agent's knowledge about the different aspects of an object when making inferences about the intentional structure of an action involving this object. Importantly, their answers systematically and correctly varied between situations where the agent represented the object under all relevant aspects and those where she represented only one aspect. Furthermore, in their overall performance, children were as competent as adults in their appreciation of the aspectuality of intentions.

What this study could show is that the ability to understand the aspectuality of intentions is present much earlier than previously assumed (i.e., at around 5 years of age). Thus, the current findings nicely align with work on children's understanding of other essential properties of intentions such as the understanding of intentions as concrete action plans (e.g., Schult, 2002). There seems to be no second paradox of intention after all. However, what this study leaves open is when the ability to understand the aspectuality of intentions emerges. We know that the ability is present in 5-year-olds—but when does it emerge? To get a more comprehensive developmental picture, in the following study we examined 4-year-olds' ability to consider the aspectuality of intentions with suitably modified tasks.

Study 2

The aim of Study 2 was to explore the emergence of the understanding that intentions are aspectual. Do 4-year-olds, similarly to the 5- and 6-year-olds from Study 1, already appreciate their own and another person's knowledge about the different aspects of an object when ascribing intentions? To this end, we tested the younger children in a structurally analogous but simplified task. The main modifications to the original task from Study 1 were that we shortened the animal selection phase (i.e., the first game), changed the names of the second identity from "Blickets" and "Zickets" to "Losers" and "Winners," and exchanged the Blicket–Zicket detector with a book that contained a list indicating which animals were Losers and which animals were Winners. With the implementation of

Table 2
5- and 6-year-olds' pattern of answers on first- and second-order false belief understanding and the intention test question.

		Intention test question: Mean proportion of answer "no"								
		0	.13	.25	.38	.50	.63	.75	.88	1
First-order false belief	0	0	0	0	0	1	0	0	0	1
	1	3	0	1	0	6	1	3	7	17
Second-order false belief	0	2	0	1	0	0	0	0	1	6
	1	1	0	0	0	6	1	3	6	11

these changes, we maintained the general structure and design of the original task but further reduced unnecessary linguistic and working memory demands.[5]

Method

Participants

A total of 42 4-year-olds (48–59 months, $M = 53.19$ months, $SD = 3.57$; 20 male) were recruited from the same databank as in Study 1. Two female participants needed to be excluded from analysis because of technical problems.

Design and procedure

In parallel with Study 1, children received a 2 (Valence: neutral or negative) × 2 (Condition: experimental or control) × 2 (Test Question: epistemic or intention) × 2 (Perspective: first-person or third-person) mixed design with valence, test question, and perspective as within-participants factors. Children were randomly assigned to either the experimental or control condition. Just as before, participants received eight trials in counterbalanced order and answered both the epistemic and intention test questions for each trial. Preceding these trials, children received two location change false belief tasks following the same procedure as described in Study 1.

Experimental condition. Like in Study 1, the experiment involved two parts: first, choosing the farm animals and, second, the sticker collection game that was unknown during the first part. To adjust to participants' younger age, the procedure was simplified. First, to reduce the duration of the first phase, the farm building context was left out and the puppet simply invited children to pick animals from a bowl. Second, to facilitate memorizing and understanding the animals' second identities and their consequences, we changed the original labels (Blicket and Zicket) to the more acquainted and self-explanatory terms Loser and Winner. Third, we modified the process of identifying the second identity to be less complex and shorter. Therefore, the Blicket–Zicket detector was replaced with a dictionary-like book. The book was introduced as containing the corresponding second identities for all animals, which enabled the experimenter to look up every animal's second identity. Fourth, to avoid the indirect information provided by the tablet and to enhance vividness, the stickers were put directly on the table instead of depicting their number via the tablet.

Implementing these changes, the procedure went as follows. After the puppet suggested picking animals to play with, children and the puppet each chose four wooden farm animals out of the bowl. This was then followed by the sticker collection game of which neither children nor the puppet had heard before. They were first informed about the rules of the game. Just like Blickets and Zickets, all Losers induced the loss of one smiley sticker, while Winners did not change the number of stickers. After the introduction to the game, children were asked comprehension control questions about the function of Losers and Winners to ensure that they understood the game. Wrong answers to the control questions were corrected by the experimenter. According to the number of animals, eight stickers were then put in the middle.

Then, each animal's second identity was looked up in the book successively. Following the rules, Winners did not affect the number of stickers, whereas for each Loser one sticker was removed. As in Study 1, after each animal, the experimenter said, "You (the puppet) intentionally chose a [animal]. The [animal] is also a Loser/Winner." Again, after this, children answered both test questions for the respective animals:

- *Epistemic:* Did you (the puppet) know that the [animal] was also a Loser/Winner?
- *Intention:* Did you (the puppet) intentionally choose a Loser/Winner?

In the end, the remaining stickers were distributed between children and the puppet.

[5] The changes emerged as the result of two pilot studies aimed at adapting the original task to a suitable format appropriate for younger children. A description of these pilot studies can be found in the online supplementary material.

Control condition. Just as in Study 1, the control condition differed from the experimental condition only in that children were informed about the sticker collection game and the animals' second identities before choosing the animals. To further stress membership, both identities were marked with either a blue or red sticker (which color marked which second identity was counterbalanced across children). Again, children's prior knowledge allowed them to freely choose the proportion of Losers and Winners. Of 20 children, 13 chose four Winners and no Losers, resulting in an unbalanced sample size for the first-person trials.

Results

As in Study 1, we computed proportion of "no" answer scores based on children's answers to the two test questions. Means of these scores as a function of condition, valence, perspective, and test question are depicted in Fig. 2.

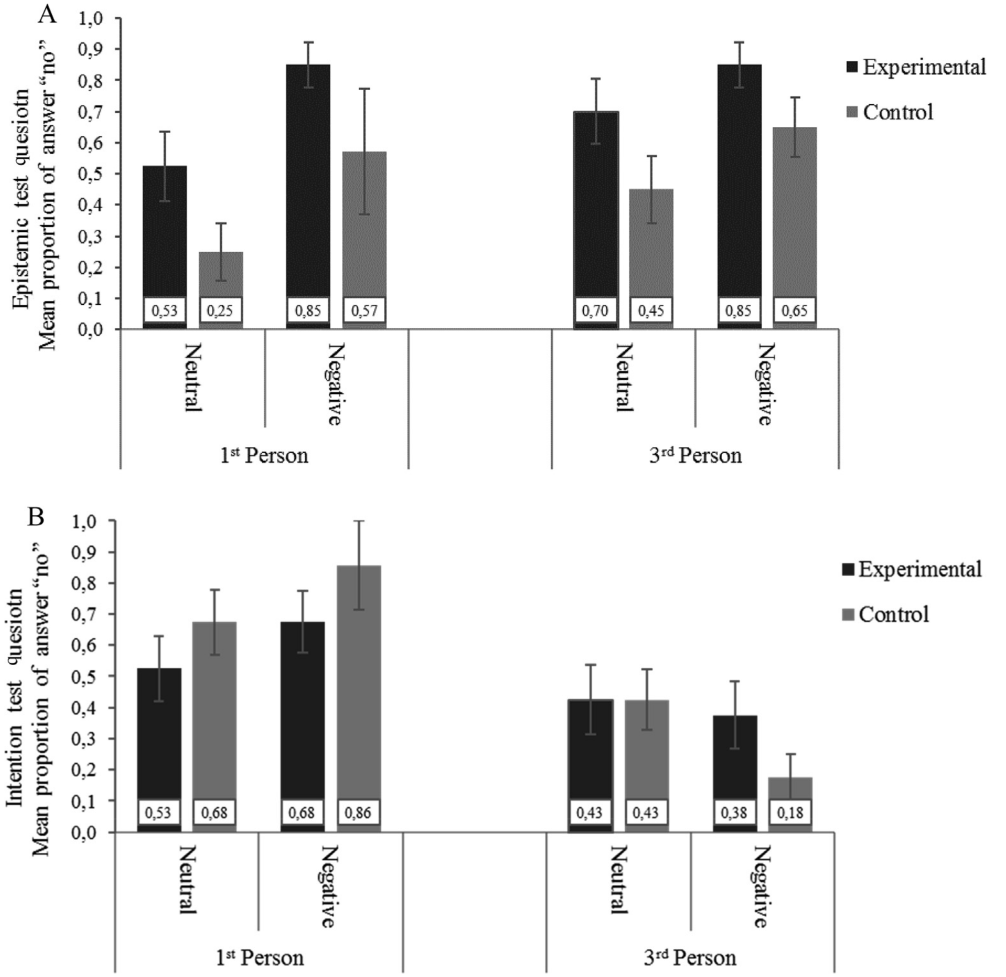

Fig. 2. Mean proportions of "no" answers to the epistemic (A) and intention (B) test questions for the experimental and control conditions. Error bars display ± 1 standard error.

Plan of analysis

In Study 2, we followed the same plan of analysis as in Study 1. We first compared participants' answers in the experimental and control conditions by conducting an ANOVA. Second, children's performance in the experimental condition was analyzed via planned one-sample *t* tests. Third, we looked at the relation between answers in the main task and in the false belief task.

Experimental condition versus control condition

As in Study 1, the central research question was how much 4-year-olds' answers differed between the experimental and control conditions. Recall that the answer "no" was clearly correct in the experimental condition for both epistemic and intention test questions. In the control condition, "no" was clearly incorrect for the epistemic test question and was at least less correct, compared with the experimental condition, for the intention test question. Accordingly, we tested whether participants gave the answer "no" more often in the experimental condition than in the control condition.

As in Study 1, children previously knew about the second identities in the control condition and 13 children did not draw any Losers, resulting in an unbalanced design. To still be able to run the statistics on the full sample size, we excluded children's answers for the negative valence of the first-person from the first analysis. Therefore, we conducted a 2 (Condition: experimental or control) × 2 (Test Question: epistemic or intention) ANOVA with the proportion of "no" answers as dependent variable.

This analysis yielded no main effect for condition, $F(1, 38) = 1.62$, $p = .211$, $\eta_p^2 = .04$, but a main effect for test question, $F(1, 38) = 7.75$, $p = .008$, $\eta_p^2 = .17$, and an interaction effect between condition and test question, $F(1, 38) = 5.19$, $p = .028$, $\eta_p^2 = .12$. Thus, overall, participants' answering behavior did not differ between the experimental and control conditions. However, the interaction effect indicates that the 4-year-olds gave the answer "no" more often in the experimental condition than in the control condition only for the epistemic test question, $t(38) = 2.23$, $p = .032$, $d = 0.70$. In contrast, for the intention test question, children gave the answer "no" equally often in both conditions, $t(38) = 0.14$, $p = .888$, $d = 0.04$. Besides, participants denied the epistemic test question more often than the intention test question.

Performance in experimental condition

In the second step of analysis, the performance of the children in the experimental condition was analyzed separately via *t* tests against chance. Overall, the 4-year-olds performed above chance on the epistemic test questions, $t(19) = 3.21$, $p = .005$, $d = 0.72$, but were at chance for the intention test questions, $t(19) = -0.63$, $p = .540$, $d = 0.14$. Thus, although they correctly denied their own and the puppet's knowledge about the second identity, they failed to also deny the intention of the action on the second identity.

False belief understanding

Children received two false belief trials. Overall, 85% of children answered both of the first-order false belief questions correctly and 7.5% answered one question correctly. Of the two second-order questions, 27.5% answered both questions correctly and 10% answered one question correctly. The contingency table (see Table 3) depicts the pattern of answers of the children in the experimental condition. The distribution indicates no systematic relation between children's performance on the false belief tasks and their answers to the intention test questions.

Discussion

The aim of Study 2 was to get a more comprehensive developmental picture of the understanding of the aspectuality of intentions. Thus, we examined 4-year-olds' competence in ascribing aspectual intentions to themselves and others in a cognitively even more simplified task. We found that, in contrast to the 5- and 6-year-olds, the younger children did not distinguish in their intentionality judgments between those situations where the agent did know and did not know about a certain aspect of the object when performing an action on that object. Furthermore, their general performance in ascribing aspectual intentions was at chance level. They were, however, competent at remembering the epistemic premises of the scenarios (epistemic questions), indicating that they understood the

Table 3
4-year-olds' pattern of answers on first- and second-order false belief understanding and the intention test question.

		Intention test question: Mean proportion of answer "no"								
		0	.13	.25	.38	.50	.63	.75	.88	1
First-order false belief	0	0	1	0	0	1	0	0	0	0
	1	0	0	0	0	0	0	1	0	1
	2	3	0	6	0	1	0	1	1	4
Second-order false belief	0	3	0	4	0	0	0	1	1	2
	1	0	0	0	0	0	0	0	0	0
	2	0	0	2	0	1	0	0	0	2

Note. Children who failed first-order false belief questions did not receive the two second-order questions and, thus, are not included in the second-order False Belief * Intention test question contingencies.

general structure of the task. In combination, these findings suggest that the 4-year-olds had a specific problem with drawing the specific inferences from these premises concerning the aspectuality of the intentions. Thus, we could not find evidence in our task that 4-year-olds grasp the aspectual nature of intentions yet.

General discussion

When do children appreciate that intentions are aspectual in the sense that they refer to objects and actions only under specific aspects? The current set of studies investigated this question with the help of a simplified interactive design. In two studies, 5- and 6-year-old children and adults (Study 1) and 4-year-old children (Study 2) were presented with a task where the same toy animals had two identities defined by their role in two consecutive games. After playing both games, children were asked about their own and a puppet's knowledge and intentions with regard to the animals' double functions. The main findings were that under suitably simplified contexts, the 5- and 6-year-olds, but not the 4-year-olds, were competent at ascribing aspectual intentions. An understanding of the aspectuality of intentions seems to develop at around 5 years of age at the latest.

Thus, these findings stand in contrast to previous work that has found that children do not make correct inferences about the aspectuality of intentions before 8 years of age (Kamawar & Olson, 2011). Why is this so? How can these diverging findings be reconciled? Most plausible, the task used in the current study was much less demanding in terms of extraneous performance factors. First, in contrast to the previous use of vignettes, the current task posed only minimal linguistic task demands. Second, in our task the children themselves were subject to the knowledge/ignorance manipulation instead of being detached third-party observers. Third, by manipulating the valence of the unknown aspect of the object, we added more relevance to the crucial test questions. This analysis receives further support by the one pattern of findings in the current studies that most closely resembled the structure of the previous study. When 5- and 6-year-olds were asked to answer the intention question from a third-person perspective and for a neutral valence, their performance dropped to chance level. This suggests that indeed the increased relevance and the more interactive testing context made the current task easier than the previous one.

So, when then do children operate with a fully fledged concept of intention—one that includes an understanding of the aspectual nature of intentions? The current findings suggest that children grasp the aspectual component at around 5 years of age at the latest. Thus, the emergence of an understanding that intentions are aspectual seems to align with children's emerging understanding of other essential properties of intentions (Astington, 1991; Baird & Moses, 2001; Phillips et al., 1998; Schult, 2002). For example, in contrast to other pro-attitudes such as desires, intentions are concrete action plans. To be satisfied, it is crucial to achieve this satisfaction exactly as intended by employing the exact means as planned. When you intend to buy a car, the intention is fulfilled only if you actually buy a car but not if someone gives you one. In contrast, there are many different ways to satisfy desires; the desire to own a car is equally satisfied by a purchase or a gift. Previous research suggests that children also come to understand these subtle but crucial properties of intentions at around age 5 (Schult, 2002): Being presented with vignettes in which a character's desire was satisfied but the intention was not (or vice versa), 4-year-olds still collapsed intentions and desires, whereas 5-year-olds systematically considered an intention to be fulfilled only if the intended action was successfully carried out. Taken together, the current and previous findings seem to converge on the idea that children come to understand most essential properties of intentions during their late preschool years.

One question that the current study leaves open is how understanding aspectual intentions relates to understanding other mental states, specifically understanding aspectual beliefs. Theoretically, appreciating the aspectuality of the agent's belief poses a necessary but not sufficient condition for ascribing a corresponding aspectual intention. Intending to perform an action X that also amounts to Y does not necessarily imply intending Y even if the agent knew that X amounted to Y. To illustrate, consider the following case. Peter intends to smoke a cigarette. He knows that this will increase his risk of lung cancer. Did he intend to raise his risk of lung cancer? In a certain sense, this was clearly not his intention. Rather, he intended to smoke only under the description "smoking" and not under the description "raising my risk of lung cancer." The underlying conceptual distinction here, as discussed in the Introduction, is between foreseen side effects and intended means (see Mikhail, 2009). Raising the risk of lung cancer, in the current example, is a foreseen side effect but nothing intended in itself. Thus, understanding under which aspects an agent represented objects and actions in her or his beliefs is a necessary precondition for understanding the aspectuality of the agent's intentions. But it is not sufficient, as the distinction between foreseen side effects and intended means shows.

From a developmental point of view, this raises the interesting question of whether this constellation (appreciating the aspectuality of beliefs being a necessary but not sufficient condition for ascribing aspectual intentions) is mirrored in cognitive ontogeny. Does an understanding of the aspectuality of beliefs underlie and precede the understanding of the aspectuality of intentions? Unfortunately, from the current design alone, we cannot conclusively tell. However, one might argue that the lack of relation between children's performance in the standard false belief task and the performance in the intention task could be seen as a first tentative clue for such a pattern. Even though the 4-year-olds showed ceiling performance in the false belief task, they showed only chance performance in the intention task. Unfortunately, the two tasks differ on too many dimensions to license conclusive inferences that making correct action predictions based on the agent's false belief is not a sufficient prerequisite for ascribing intentions from this pattern. Most notably, the two tasks measured different types of beliefs (location false belief in the standard task and aspectual beliefs in the intention task). Even though previous work has shown high correlations between children's performance in location false belief tasks and that in aspectual false belief tasks (see Rakoczy et al., 2015), the evidence is far too indirect. Thus, an interesting next step for future research would be to further explore the cognitive foundation of the relation between aspectual intentions and aspectual beliefs. Ideally, such research would directly compare children's performance in structurally similar aspectual false belief and aspectual intention tasks.

In conclusion, the current findings show that children develop an understanding of the aspectuality of intentions significantly earlier than previously assumed. Taken together with previous findings, the picture that emerges suggests that children acquire a general metarepresentational understanding of intentions at around 5 years of age. Future research will need to investigate more systematically how such an understanding of (the aspectuality of) intentions relates to an understanding of other propositional attitudes and to other forms of social cognition such as intent-based moral evaluation of actions over the course of development.

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Appendix A. Output from the 3 (Age: 5-year-olds, 6-year-olds, or adults) × 2 (Condition: Experimental or control) × 2 (Test Question: Epistemic or intention) × 2 (Valence: Neutral or negative) ANOVA with the proportion of "no answers as dependent variable

	F	*df*	*p*	η_p^2
Age	0.461	2, 112	.632	.008
Condition	86.447	1, 112	<.001	.436
Test question	0.958	1, 112	.330	.008
Valence	12.825	1, 112	.001	.103
Age * Condition	2.581	2, 112	.080	.044
Age * Test Question	0.174	2, 112	.841	.003
Age * Valence	0.303	2, 112	.739	.005
Condition * Test Question	5.415	1, 112	.022	.046
Condition * Valence	0.327	1, 112	.569	.003
Test Question * Valence	2.205	1, 112	.140	.019
Age * Condition * Test Question	0.044	2, 112	.957	.001
Age * Condition * Valence	0.133	2, 112	.876	.002
Age * Test Question * Valence	1.424	2, 112	.245	.025
Condition * Test Question * Valence	0.059	1, 112	.808	.001
Age * Condition * Test Question * Valence	1.180	2, 112	.311	.021

Appendix B. Output from the 2 (Age: 5-year-olds or 6-year-olds) × 2 (Condition: Experimental or control) × 2 (Test Question: Epistemic or intention) × 2 (Valence: Neutral or negative) × 2 (Perspective: first-person or third-person) ANOVA with the proportion of "no answers as dependent variable on the reduced sample size (*N* = 67)

	F	*df*	*p*	η_p^2
Age	0.731	1, 63	.396	.011
Condition	54.168	1, 63	<.001	.462
Test question	2.613	1, 63	.111	.040
Valence	6.456	1, 63	.014	.093
Perspective	3.240	1, 63	.077	.049
Age * Condition	1.116	1, 63	.295	.017
Age * Test Question	0.007	1, 63	.935	.000
Age * Valence	0.443	1, 63	.508	.007
Age * Perspective	0.074	1, 63	.787	.001
Condition * Test Question	5.946	1, 63	.018	.086
Condition * Valence	0.033	1, 63	.857	.001
Condition * Perspective	1.022	1, 63	.316	.016
Test Question * Valence	0.000	1, 63	1.000	.000
Test Question * Perspective	5.210	1, 63	.026	.076
Valence * Perspective	2.445	1, 63	.123	.037
Age * Condition * Test Question	0.169	1, 63	.682	.003
Age * Condition * Valence	0.717	1, 63	.400	.011
Age * Condition * Perspective	0.220	1, 63	.641	.003
Age * Test Question * Valence	1.654	1, 63	.203	.026

(*continued on next page*)

Appendix B (*continued*)

	F	df	p	η_p^2
Age * Test Question * Perspective	1.541	1, 63	.219	.024
Age * Valence * Perspective	0.076	1, 63	.784	.001
Condition * Test Question * Valence	0.066	1, 63	.798	.001
Condition * Test Question * Perspective	2.439	1, 63	.123	.037
Condition * Valence * Perspective	0.846	1, 63	.361	.013
Test Question * Valence * Perspective	4.327	1, 63	.042	.064
Age * Condition * Test Question * Valence	2.381	1, 63	.128	.036
Age * Condition * Test Question * Perspective	1.002	1, 63	.321	.016
Age * Test Question * Valence * Perspective	0.135	1, 63	.715	.002
Age * Condition * Valence * Perspective	0.000	1, 63	1.000	.000
Condition * Test Question * Valence * Perspective	0.060	1, 63	.807	.001
Age * Condition * Test Question * Valence * Perspective	0.539	1, 63	.466	.008

Appendix C. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jecp.2018.12.001.

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