

Children's Attributions of Intentions to an Invisible Agent

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Children ages 3–9 years were informed that an invisible agent (Princess Alice) would help them play a forced-choice game by “telling them, somehow, when they chose the wrong box,” whereas a matched control group of children were not given this supernatural prime. On 2 unexpected event trials, an experimenter triggered a simulated unexpected event (i.e., a light turning on/off; a picture falling), and children's behavioral response to these events (i.e., moving their hand to the opposite box) was coded. Results showed a significant Age Group \times Experimental Condition interaction; the only children to reliably alter their behavior in response to the unexpected events were the oldest children ($M = 7$ years 4 months), who were primed with the invisible agent concept. For children's posttest verbal explanations, also, only these children saw the unexpected events as being referential and declarative (e.g., “Princess Alice did it because I chose the wrong box”). Together, these data suggest that children may not regularly begin to see communicative signs as embedded in unexpected events until they are around 7 years of age.

Keywords: causal reasoning, intentionality, theory of mind, explanation

Do children reason about chance happenings the way that many adults seemingly do, by seeing personal messages or “signs” in events such as tsunamis, sickness, lottery winnings, and car accidents (Bering, 2002, 2003; Pepitone & Saffiotti, 1997)? If it is like any other representational competency, then the ability to represent natural events as symbolic (as being about something other than the event itself) should display developmental patterns (DeLoache, 1987). It may also bootstrap changes in other areas of cognitive development such as a growing social competence that hinges on reading the intentions and desires of a communicative partner and understanding that others may see the world differently than the self.

In the everyday social world, meaning is inferred through others' actions, where behaviors carry information about unobservable mental states (Baldwin & Moses, 1996; Baron-Cohen, 1995; Bruner, 1990; Gopnik & Meltzoff, 1997; Nelson, Plesa, & Henseler, 1998). Communicative behaviors — from a coquettish grin to an angry elbow in the stomach — are about something other than the action itself. In other words, they are *referential*. A coquettish grin may refer to a potential suitor's display; an angry elbow in the stomach may refer to a bad call in a football match. In addition, communicative behaviors are *declarative*. That is, communicative behaviors are motivated by a partner's intentions to share some information with the self and, ipso facto, are caused by the hidden psychological properties of this other person's mind—in the previous examples, a woman's romantic interest or a rival player's discontent.

Using a variety of tasks, developmental psychologists have shown that young children can make attributions of communicative intentions before their third birthday. For instance, in one experimental paradigm, children are tested to see whether they can find a hidden object by relying solely on the referential behaviors of an experimenter, such as eye gaze or pointing, that are carefully and systematically manipulated in laboratory settings (e.g., Caron, Kiel, Dayton, & Butler, 2001; Povinelli, Reaux, Bierschwale, Allain, & Simon, 1997; Tomasello, Call, & Gluckman, 1997). These are tests of social-cognitive functioning because such tasks require that the child reason about the communicative intentions of the experimenter in producing these referential actions.

The cumulative evidence in this area suggests that, by roughly 2.5 years of age, children quite effortlessly represent the experimenters' actions (e.g., an index finger directed at one of several boxes that may contain a prize) as being referential (e.g., about the correct box) and are able to find the hidden object by exploiting these social cues (for a review, see Butterworth, 2003). Young children pass such tasks even if the gesture is distally removed from its referent (Povinelli et al., 1997) or is obscured from its referent by a barrier of some sort (Caron et al., 2001), thus supporting the claim that young children possess a genuine understanding of other people's communicative behaviors as being about their intentions to share information.

Abstract Intentional Agency

When it comes to “existential” matters, people similarly infer intent and meaning, but in this case, the communicative messages are seen as being transmitted in the form of ambient, natural events rather than behaviors (Bering, 2002, 2003). One doctoral-level student from a New Orleans seminary, for instance, suggested that God meant Hurricane Katrina to be a “wake-up” call for residents of a city so notoriously “bogged down in sin” (Roach, 2005). From all appearances, this form of causal reasoning—in which certain occurrences are seen as being motivated by the communicative

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intentions of a supernatural agent—is culturally ubiquitous (for a review, see Bering & Johnson, 2005). As far as researchers are aware, however, there have been no controlled experimental studies that have directly investigated children’s capacity to see supernatural signs as being embedded in naturally occurring events.

In regard to this particular question, there are three broad ways that an individual may mentally represent the cause of any given event (note that this applies equally across event domains, being relevant to physical, social, and biological events):

1. Natural causality. An event may be represented as being exclusively caused by proximally occurring, natural forces. For instance, if a picture were to suddenly crash to the floor, then an individual may, in this case, reason that the event was caused by a mechanistic fault or physical defect in the object’s supporting device or that the nail on the wall was old and became unhinged. The explanation may not have veracity (i.e., it may be patently wrong), but it still draws from the repository of ontologically natural causal forces.

2. Intentional agentive. An event may be represented as being intentionally caused by an abstract, invisible agent without any communicative purpose associated with the event. For instance, for the same event, an individual may, in this case, reason that an unobservable supernatural force (e.g., a spirit, ghost, witch, or deity) intentionally caused the picture to crash to the floor, for no other reason than that it could or that it desired to.

3. Declarative agentive. An unexpected event may be represented as being intentionally caused by an abstract, invisible agent who is purposefully communicating a personal message, embedded in the event, to the individual. For instance, in this case, the supernatural agent would be envisioned as having caused the picture to crash to the floor because it meant to share some specific information with the individual. Thus, the unexpected event becomes a mode of supernatural communication, similar to natural communication of language, eye gaze, or pointing.

These general causal frameworks are not mutually exclusive. There is no reason to assume, for instance, that an individual who possesses the cognitive capacity to make a declarative agentive causal attribution (i.e., seeing a natural event as a supernatural sign) would not also have the psychological means to reason about the natural cause of the event. Spiritual leaders who tried to interpret the recent tsunamis of East Asia for “meaning” are an example of this: Their explanations did not imply that they lacked the capacity to understand that the tsunamis were naturally and proximally caused by the shifting of tectonic plates on the ocean floor (nor were these spiritual explanations simply because of a poverty of accurate scientific information). Similarly, by invoking a declarative agentive explanation, an individual is simultaneously demonstrating the capacity for intentional agentive causal reasoning. To understand that another agent is trying to communicate information first requires a basic understanding that other agents act intentionally. However, each of these causal frameworks seemingly involves an increasingly sophisticated set of cognitive abilities.

In the present study, we investigated the ontogenetic emergence of the capacity to make meaning-based attributions in response to simulated unexpected events (e.g., a picture falling, a light flashing on and off) occurring in the laboratory. An event such as a picture falling to the floor is not, in itself, a communicative event; it can become so only through the phenomenal properties of the child’s

mind (“what is the *meaning* of the picture crashing to the floor, precisely at this moment in time?”). Because the development of this type of causal reasoning had not previously been empirically investigated, in the present study, we primarily sought to determine the age at which children begin to view unexpected events as being declarative and referential—intentionally caused by an abstract agent in order to share information with them and as referring to something in the environment other than the event itself.

To accomplish this, we had 3- to 9-year-old children play a simple game in which they were to guess the location of a hidden ball by placing their hand on top of the box (out of a pair of boxes) that they believed contained the ball. Prior to the game, however, and immediately before each trial, an experimental group of children was told that there was an invisible agent (Princess Alice) in the room “who will tell you, somehow, when you choose the wrong box.” The control group of children simply went about the task without any information about this invisible agent. More important, the events chosen were not “magical” in the sense that they were obvious violations of ontological law (e.g., an object disappearing from a box or being conjured up from thin air; cf. Subbotsky, 2001) but were instead unexpected events that could occur in the real world. In other words, just as they may occur outside the laboratory, the events were possible, infrequent events rather than impossible, inexplicable occurrences. Children’s behavioral responses (i.e., whether they moved their hand in response to the unexpected events) as well as their posttest verbal judgments of these events served as the primary dependent measures.

One very general hypothesis was that, regardless of age, children who were assigned to the control group, and hence did not receive any information concerning an invisible agent in the room, would fail to treat the unexpected occurrences as symbolic. Although it is an interesting question in its own right whether conceptual primes dealing with specific invisible agents are required for people to see symbolic meaning in natural events (see Boyer, 2001), it seemed likely to us that such primes would, in fact, be required for such attributions to occur reliably under laboratory conditions. Therefore, we predicted that children in the control group would not move their hands to the opposite box in response to such events or explain the events as being related to the task at hand. In contrast, children who were randomly assigned to the experimental condition, and therefore received the invisible agent prime, would view the unexpected occurrences as symbolic. Thus, their behavioral responses on the hiding game task and their posttest verbal judgments of the unexpected events would reflect attributions of intentions (e.g., “The picture fell because I chose the wrong box”).

Method

Participants

One hundred fifty-one children (79 boys and 72 girls) ranging in age from 3 years 0 months to 9 years 7 months participated. All children were from the Northwest Arkansas area whose parents learned of the study through community-wide announcements or were identified from public birth records as having children within this age range and then recruited through telephone calls. Although the religiosity and ethnicity of the parents and children were not recorded, the primary religious denomination in the Northwest Arkansas region is Baptist (Methodism and Presbyterianism are also common), and the area consists predominantly of Caucasian individuals.

Children were divided into three groups on the basis of age. The "youngest" group consisted of children between the ages of 3 and 4 years, the "middle" age group consisted of children between the ages of 5 and 6 years, and the "oldest" group consisted of children between the ages of 7 and 9 years. Levene's test indicated that the variance of age scores was approximately equal for the control and experimental groups, $F(1, 148) = 1.29, p = .26$. There were no significant differences in age, $F(1, 148) = 3.16, p = .08, \eta^2 = .02$ ($M = 5.98, SD = 1.67$ for the control group; $M = 5.53, SD = 1.43$ for the experimental group), age group membership (i.e., youngest, middle, or oldest group), $\chi^2(2, N = 151) = 2.41, p = .30, \Phi = .13$, or gender, $\chi^2(1, N = 151) = 1.05, p = .30, \Phi = .08$, between the experimental and control groups.

In the experimental group, there were 32 children in the youngest age group (17 boys and 15 girls; $M = 4$ years, 1 month; range = 3 years 0 months–4 years 9 months), 26 children in the middle age group (14 boys and 12 girls; $M = 5$ years 5 months; range = 5 years 0 months–6 years 9 months), and 22 children in the oldest age group (14 boys and 8 girls; $M = 7$ years 4 months; range = 7 years 0 months–7 years 9 months). In the control group, there were 20 children in the youngest age group (11 boys and 9 girls; $M = 3$ years 7 months; range = 3 years 1 month–4 years 6 months), 29 children in the middle age group (11 boys and 18 girls; $M = 5$ years 9 months; range = 5 years 0 months–6 years 7 months), and 22 children in the oldest age group (12 boys and 10 girls; $M = 7$ years 9 months; range = 7 years 0 months–9 years 7 months).

Materials

Children were tested individually. Parents were fully informed about the procedure (including being told about the specific unexpected events that were to occur) and were encouraged to leave the laboratory room during testing and to observe the experimental session via an online video feed projected onto a TV monitor located in an adjacent room. In those cases in which parents felt more comfortable being in the room with their child during testing, parents were told to provide a secure base for their child only and to refrain from commenting on the events during the procedure. Approximately half the parents chose to remain in the room. Although this variable was not recorded or analyzed, there were no observed instances in which parents interfered with the procedure.

Children were asked to play a game in which the experimenter hid a medium-sized ball inside one of two identical, large (30 cm³) wooden boxes, placed side by side atop a table and separated by a distance of approximately 40 cm. (Children were unaware that there were actually two identical balls, one inside of each box, and the experimenter had determined prior to the start of the session whether the child would choose the "correct" box on any given trial, see below.)

Procedure

All children were shown one ball and given the following instructions:

I'm going to hide this ball inside one of these two boxes. While I'm hiding it, you're going to go to the corner and hide so that you don't see where I put it. Then you're going to come back and guess where the ball is by placing your hand on top of the box that you think it's inside—like this (experimenter then demonstrated placing her hand, palm side down, on top of the box). Now, if you change your mind, you can move your hand. So, let's say at first you think the ball is in this box (experimenter places her hand on Box A), and then you think, no, maybe it's in the other box, then you can move your hand—like this (experimenter then demonstrated moving her hand from Box A to Box B). You just have to keep your hand on one of the boxes at all times. But wherever your hand is when I say "Time's Up!" is your final choice. If you get it right, then you get to pick a sticker, but if you get it wrong, then you don't get a sticker.

Children were also informed of two important procedural rules. First, they were not allowed to open up the boxes themselves, and second, they had to remain on the side of the table opposite the experimenter. After hearing the instructions, children were administered a training trial to make sure that they understood the basic rules of the game. Several children required more than one training trial to master the complexities of the task. In all cases, testing did not proceed until the child demonstrated the appropriate behavioral response (i.e., limiting their choice to only one of the two boxes, keeping their hand on a box at all times other than to change locations) on a training trial. Despite this training, a total of 12 children (4 from each age group) were unable to follow the rules of the game, and, therefore, these data are not included in the analyses. Failure to follow the rules included simultaneously placing hands on both boxes, pointing to a box rather than placing a hand on a box, and rapidly moving a hand from box to box such that the unexpected event occurred while the child's hand was equidistant between them.

For the training trial, and for all subsequent testing trials, the experimenter "hid" the ball inside the single empty box (which began on the left and then, whether right or left, would be determined by the child's prior response). The experimenter then stated, "Ok, pick whichever box you think the ball's in" to cue the child, who was hiding with his or her back to the experimenter. Once the child's hand had made physical contact with one of the boxes, the experimenter began timing the trial, which for all trials lasted 15 s. During this period, the experimenter maintained a neutral expression, avoided eye contact with the child, did not speak to the child unless it was necessary to remind him or her to keep a hand on one of the boxes, and looked at her timer while administering the trial.

After 15 s elapsed, the experimenter told the child, "Ok, let's see where the ball is," and then proceeded to open up one of the boxes. To help establish that there was a "wrong" and "right" choice, all children were told that they chose the wrong box on the training trial regardless of the box they had their hand on at the end of the trial. At the end of this and every subsequent trial in which participants were told they had chosen the wrong box, the experimenter opened only the box that the child did not select (e.g., "No, it was in here this time, look!"), keeping the box that the child selected closed in order to prevent him or her from learning that there were actually two balls.

Invisible agent concept. After the training trial, children who were randomly assigned to the experimental group ($n = 80$) were shown a medium-sized picture that hung on the back of the door to the laboratory room. The picture was a portrait of a friendly, make-believe (i.e., two-dimensional cartoon) female character wearing jewels and a crown. Children were then told the following story:

See this picture? This is a picture of Princess Alice. Isn't she pretty? Princess Alice is a magic princess. Do you know what she can do? She can make herself *invisible*. Do you know what invisible means? [Either, "that's right, it means you can't see her" or "it means you can't see her, even though she's there," depending on the child's response.] And guess what, Princess Alice is in the room with us right now. Where do you think she is? [If necessary, the experimenter then prompted the child by pointing to various areas of the room while asking, "Do you think she's over there, or over there? Remember, we can't see her."] And guess what else, Princess Alice really likes you and she's going to help you play the game. She's going to tell you when you pick the *wrong* box. I don't know how she's going to tell you, but somehow she's going to tell you when you pick the wrong box.

Children who were randomly assigned to the control group ($n = 71$) heard nothing of Princess Alice but instead proceeded directly onto the hiding game task.

Unexpected events. Each test session contained four trials—two unexpected event trials and two nonevent trials. For children in the experimental group, prior to the child's guess on each of the trials, the experimenter

provided a verbal reminder, “Now remember, Princess Alice will tell you when you pick the *wrong* box” (Children in the control group received no such prompt.) The placement of the unexpected event trials within sessions was completely counterbalanced. All trials were identical to the single training trial, with the following exceptions: The unexpected event trials involved one of two “random” occurrences in the laboratory, an *iconic event* (i.e., the picture of Princess Alice falling off the door, caused by a hidden experimenter covertly lifting a magnet on the other side of the closed door to which the metal frame of the picture was attached) and an *ambiguous event* (i.e., a table lamp turning on and off in rapid succession, twice, caused by an experimenter in a separate room with a remote control switch to an adapter connected to the lamp), both of which were meant to appear as communicative signs from Princess Alice that the child had chosen the wrong box. For all unexpected event trials, the timing of the unexpected events was immediately contingent with the child’s hand first making physical contact with one of the boxes.

In response to the unexpected events, the experimenter briefly turned to the object involved (either the light or the picture) and feigned slight surprise but otherwise did not react to the event with strong emotion or to any questions the child might have had or comments he or she might have made at that time. The objects used in the unexpected event trials were returned to their original, pretrial positions following these trials—the picture of Princess Alice was replaced on the back of the door and the table lamp was reset to the off position. This was done to suggest to the children that the likelihood of occurrence of these two unexpected events was equal across all trials.

Test sessions were videotaped and observed online from a video monitor in an adjacent room so that the second experimenter knew when to trigger the unexpected events.¹ All children experienced both types of unexpected events, a single time each, during their test sessions. For the remaining two nonevent trials during each session, neither of these unexpected events occurred.

On the unexpected event trials, children were told they had picked the correct box and received a prize (i.e., a sticker) only if, at the end of the 15-s trial, their hand was on the box opposite that which it was on at the time the unexpected event occurred. If they did not move their hand on the unexpected event trials, or moved their hand several times so that it ended up on the same box they had originally selected, then children were told that they had chosen the wrong box and they did not receive a prize. In order to discourage a simple operant response in which the children merely associated a wrong choice with “something” happening in the environment and a right choice with “nothing” happening in the environment, children were always told that they had selected the correct box on the two nonevent trials and received a reward regardless of whether they moved their hand during these trials. This, in combination with the complete counterbalancing of the unexpected event trials, served as safeguards against association explanations for choosing the correct box.

Verbal judgments. Following the four trials (i.e., two unexpected event trials and two nonevent trials), children were asked to provide verbal causal explanations for the unexpected events. The experimenter asked the child, “Do you remember when the picture of Princess Alice fell off the door [the lights went on and off]? Why do you think that happened?” (The order of questions dealing with the unexpected events was determined by their counterbalanced order in the test session so that those children who saw the lights flicker on and off before the picture fell were asked about the lights first during this phase of the study, whereas those who saw the picture fall before the lights flickered were first asked about the picture.) Depending on the child’s initial response to these questions, the experimenter asked follow-up questions to encourage the child to articulate a response that could be appropriately coded as falling within a particular causal category (see *Coding of verbal judgments* section). Children who initially stated that they did not know why the unexpected event occurred, or otherwise did not provide an answer to the experimenter’s question, were encouraged to provide an explanatory answer a second time (e.g., “Do you have any idea

why it happened?”). No child was forced to provide an explanation beyond this minor coaxing. To prompt a verbal judgment, those children who pointed to the picture of Princess Alice were asked what they were pointing to. Children who provided an agentive causal response (e.g., “Princess Alice did it”) were asked further, “Why do you think she did that?”

Following the verbal judgment portion of the study, children from the experimental group were informed that Princess Alice was only make-believe, and all children were further debriefed by showing them how the unexpected events were actually made to occur.

Coding of verbal judgments. Posttest verbal judgments were classified by explanatory type, and actual examples of children’s verbal judgments are illustrated in the Appendix.

For those cases in which a child spontaneously gave two or more distinct explanatory types, their final verbal judgment—their resting explanation—was the one classified and included in the analyses. For instance, a child might at first have provided no explanation (e.g., “I don’t know”), and then upon thinking for a moment might have given a physical explanation (e.g., “I bet [the picture fell] because it wasn’t sticky enough”). The one exception to this rule was the agentive category. If a child provided either an intentional agentive or declarative agentive explanatory type at any point in the verbal judgment phase of the study, then this explanation was the one included in the analyses, even if it was followed by a nonagentive explanation. This selectively liberal coding system meant that for a child’s response to be scored as indicating neither agentive explanatory type meant that these verbal judgments did not occur at any time during the questioning.

Jesse M. Bering and a second person naïve to the purposes of the study served as independent coders for the verbal judgment data from the experimental condition. Initial interrater reliability was 91% (Cohen’s $\kappa = .822$), and all disagreements were subsequently resolved by reviewing the episodes in question.

Results

Description of Behavioral Measures

We used two primary behavioral measures in the present study. First, *receptive responding* meant that, at the end of the 15-s trial, a child’s hand was on the box opposite from the box it was on at the time the unexpected event occurred. For example, a child was coded as responding receptively to Princess Alice’s “messages” if his or her hand was on Box A when the unexpected event occurred and on Box B (or vice versa) at the end of the 15-s trial (regardless of how many times his or her hand moved during that time period). This measure of receptive responding, by virtue of its definition, was only coded for the two unexpected event trials. This operational definition of receptive responding was, in our view, the best possible indication that the child altered his or her behavior because of the unexpected event. In other words, it suggested that the child viewed the unexpected event as being about a wrong initial choice (i.e., a sign).

In contrast, a second behavioral measure, *hand movements*, was coded for both unexpected event and nonevent trials. Because there were two unexpected event trials (one ambiguous and one iconic event), there were three possible response profiles for each child: (a) the child does not move her or his hand for either of these

¹ For the iconic event (picture of Princess Alice falls), the experimenter in the room gave an auditory cue (i.e., throat clearing) to the experimenter on the other side of the door as soon as the child’s hand first made contact with one of the boxes. None of the participants mentioned this auditory cue, suggesting that they did not recognize its role in the experiment.

trials, (b) the child moves her or his hand for only one of these trials, and (c) the child moves her or his hand for both of these trials (and likewise for the two nonevent trials). (Note that it was not the raw number of times the child moved his or her hand within each 15-s trial or the mean number of times the child moved his or her hand within a single trial type.) Thus, this measure reflected the general occurrence of hand movements within a collapsed trial type and could be compared across the two trial types (hand movements on unexpected event trials vs. hand movements on nonevent trials).

The primary purpose of including this hand movement measure was to determine whether the verbal reminder provided to children in the experimental group immediately before each 15-s trial ("Now remember, Princess Alice will tell you when you choose the wrong box") may have led to more frequent receptive responses, but only because it triggered thoughts of uncertainty not because of Princess Alice per se. In other words, this "low-level" account implies that this verbal reminder may have made children in the experimental group more likely to move their hands than children assigned to the control group—who (obviously) did not receive this verbal reminder—only because it made them more likely to question their initial choice, not because they saw communicative intent in the unexpected events. If this low-level account is correct, then we would expect children from the experimental group to move their hands more frequently than those from the control group on both the unexpected and nonevent trials because for the former, each of the four trials was immediately preceded by the verbal reminder.

Preliminary Analyses

Because there was no significant gender difference for responding receptively (i.e., child's hand was on the box opposite from the one it was on at the time the unexpected event occurred) on unexpected event trials (i.e., receptive responses to none, one, or both of the unexpected trials), $\chi^2(2, N = 151) = 0.16, p = .92$ ($\Phi = .03$), data were collapsed across gender. Preliminary analyses also revealed that the sequence of the four trials (i.e., one ambiguous event, one iconic event, and two nonevent trials; 12 possible sequences) had no significant effect on children responding receptively on the unexpected event trials, $\chi^2(11, N = 151) = 13.94, p = .24$ ($\Phi = .30$), and so all further analyses were collapsed across this variable as well.

Analyses revealed that the order of the two unexpected event trials (i.e., the picture falling, then the light going on and off, or vice versa) had no significant effect on children responding receptively on the unexpected event trials (i.e., receptive responses to none, one, or both of the unexpected trials), $\chi^2(2, N = 151) = 1.09, p = .58$ ($\Phi = .09$). Also, there was no significant difference in receptive responding on the basis of whether the first trial was an unexpected event trial or a nonevent trial, $\chi^2(2, N = 151) = 3.62, p = .16$ ($\Phi = .16$).

Receptive Responding to Unexpected Events

In order to examine the influence of condition and age group on receptive responding to unexpected events (i.e., child's hand was on the box opposite from the one it was on at the time the unexpected event occurred), an analysis of variance (ANOVA)

was conducted, with the type of unexpected event collapsed (i.e., iconic and ambiguous) as the dependent variable (i.e., receptive responses to none, one, or both of the unexpected trials). Levene's test of equality of error variances (i.e., tests the null hypothesis that the error variance of the dependent variable is equal across groups) was not significant, $F(5, 145) = 1.81, p = .12$.

Analyses revealed a significant interaction between condition (i.e., experimental vs. control groups) and age group (i.e., youngest, middle, oldest) on mean number of receptive responses to unexpected event trials (see Figure 1), $F(2, 145) = 7.66, p = .001, \eta^2 = .10$; a significant main effect of condition, $F(1, 145) = 20.49, p < .001, \eta^2 = .12$ (experimental > control); and a significant main effect of age group, $F(2, 145) = 9.34, p < .001, \eta^2 = .11$ (oldest > middle = youngest). Follow-up univariate ANOVAs revealed that, for the oldest age group, children in the experimental group had a significantly higher mean number of receptive responses ($M = 1.00, SD = 0.62$) compared with children in the control group ($M = 0.18, SD = 0.39$), $F(1, 42) = 27.44, p < .001$. For the middle age group, there was no significant difference in the mean number of receptive responses between children in the control group ($M = 0.14, SD = 0.35$) and children in the experimental group ($M = 0.35, SD = 0.56$), $F(1, 53) = 2.78, p = .10, \eta^2 = .05$. For the youngest age group, as well, there was no significant difference in the mean number of receptive responses to unexpected events between children in the control group ($M = 0.15, SD = 0.37$) and children in the experimental group ($M = 0.22, SD = 0.55$), $F(1, 50) = 0.24, p = .63, \eta^2 < .001$.

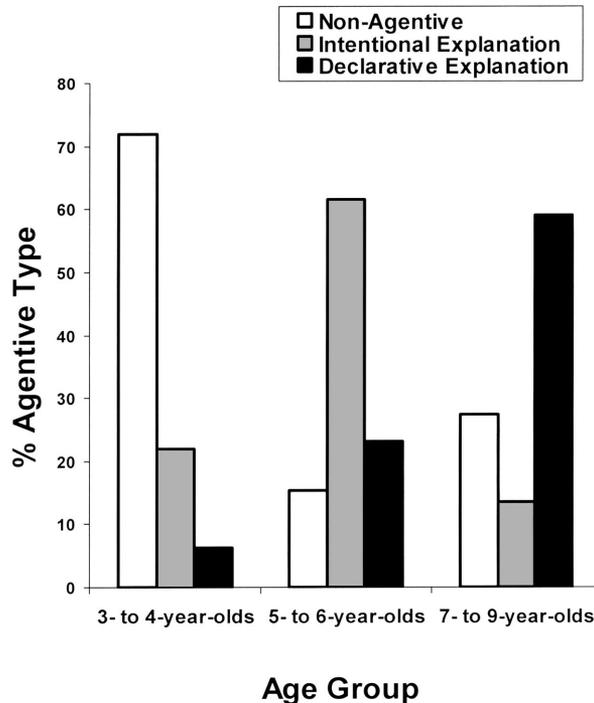


Figure 1. Behavioral change. Condition and age group comparison of mean number of receptive responses (i.e., moved hand to the box opposite the first selection following the occurrence of either the iconic or ambiguous random event) on unexpected event trials. "Youngest" = 3- to 4-year-olds; "middle" = 5- to 6-year-olds; "oldest" = 7- to 9-year-olds.

Hand Movements on Unexpected Event Trials Versus Nonevent Trials

In order to compare children's general behavioral responses on unexpected event trials (i.e., iconic and ambiguous event trials) with their responses on nonevent trials, "hand movement" data were collapsed so that each child had a score both for unexpected event trials (i.e., a score of 0 if they made no hand movements on these two trials; a score of 1 if they made hand movements to either the iconic or ambiguous event trial but not both; a score of 2 if they made hand movements on both these two unexpected event trials) and for nonevent trials (i.e., a score of 0 if they made no hand movements on the two nonevent trials; a score of 1 if they made hand movements to only one of the nonevent trials; a score of 2 if they made hand movements on both of the nonevent trials).

A three-way (Condition \times Age Group \times Trial Type) mixed-factorial ANOVA was performed, with condition (experimental vs. control group) and age group (youngest vs. middle vs. oldest) as between-subjects variables and trial type (unexpected event trial vs. nonevent trial) as a within-subjects variable. Hand movement (as described above: 0, 1, or 2 for each trial type) served as the dependent variable. According to this analysis, there was no significant main effect of condition, $F(1, 142) = 1.85, p = .18, \eta^2 = .01$, or trial type, $F(1, 142) = 0.01, p = .92, \eta^2 < .001$. However, there was a significant main effect of age group, $F(2, 142) = 7.39, p = .001, \eta^2 = .09$ (oldest $>$ middle $>$ youngest).

There was a significant Trial Type \times Condition interaction, $F(1, 142) = 5.89, p = .02, \eta^2 = .04$, and there were no Trial Type \times Condition \times Age Group, $F(2, 142) = 1.44, p = .24, \eta^2 = .02$; or Trial Type \times Age Group interaction, $F(2, 142) = 0.57, p = .57, \eta^2 = .008$. In other words, children in the experimental group were significantly more likely to move their hand on the unexpected event trials ($M = 0.68, SD = 0.81$) compared with children in the control group ($M = 0.41, SD = 0.70$), $F(1, 147) = 4.69, p = .03, \eta^2 = .03$, although there was no significant difference in whether children in the experimental group ($M = 0.55, SD = 0.78$) or control group ($M = 0.59, SD = 0.85$) moved their hands on nonevent trials, $F(1, 146) = 0.08, p = .78, \eta^2 = .001$. This allowed us to rule out a low-level account that receptive responses were triggered only by the verbal reminder provided to children in the experimental condition, because the reminder preceded both unexpected and nonevent trials.

Verbal Judgments of Unexpected Events

Because there was no significant gender difference for agentive explanatory type (i.e., nonagentive, intentional agentive, or declarative agentive), $\chi^2(2, N = 150) = 0.89, p = .64 (\Phi = .08)$, data were collapsed across gender. As with the behavioral change measure, preliminary analyses also showed no significant effect of sequence order (i.e., position of the unexpected event trials within the testing sessions; 12 possible sequences in the present study) on children's overall agentive explanation, $\chi^2(22, N = 150) = 13.39, p = .92 (\Phi = .30)$. For the control group, 67 children out of 70 provided a nonagentive explanation for both the ambiguous and iconic events. Because of this lack of variability in verbal explanations, age differences were not computed for children in the control group. For the experimental group, 26.3% of children provided a declarative agentive explanation for at least one of the

events, and 32.5% of children provided an intentional agentive explanation for at least one of the events.

Figure 2 shows age group differences for children's agentive explanation, $\chi^2(4, N = 80) = 36.82, p < .001 (\Phi = .68)$, for children in the experimental group. The youngest children provided mostly (71.9%) nonagentive verbal judgments (i.e., no explanation, physical, other person, or animistic), children in the middle age group provided mostly (61.5%) intentional agentive explanations (e.g., "Princess Alice did it, but I don't know why"), and the oldest children provided mostly (59.1%) declarative agentive explanations (e.g., "Princess Alice did it because she was trying to help me find the ball"). A significantly greater number of children in the oldest age group (59.1%) gave a declarative agentive explanation compared with children in the youngest age group (6.3%), $\chi^2(1, N = 54) = 18.41, p < .001 (\Phi = .58)$, and compared with children in the middle age group (23.1%), $\chi^2(1, N = 48) = 11.62, p = .003 (\Phi = .49)$. This same pattern (i.e., children in the oldest group being more likely to provide declarative agentive explanations relative to children in the middle and youngest age groups) was found for both the ambiguous, $\chi^2(4, N = 80) = 29.14, p < .001 (\Phi = .60)$, and iconic events, $\chi^2(4, N = 80) = 23.97, p < .001 (\Phi = .55)$. When all explanatory types were considered (i.e., none, physical, other person, animistic, intentional, and declarative), results remained the same for both the ambiguous, $\chi^2(10, N = 80) = 36.74, p < .001 (\Phi = .68)$, and iconic events, $\chi^2(10, N = 80) = 34.00, p < .001 (\Phi = .65)$.

Congruity Measures of Behavioral Change and Agentive Verbal Judgments

Table 1 shows the percentage of children in the experimental group whose receptive responses to the ambiguous event "matched" their verbal judgments on this trial. Children who gave nonagentive or intentional agentive explanations for the light turning on and off were significantly more likely to have been nonreceptive for the ambiguous event trial, whereas children who gave a declarative agentive explanation were more likely to have been receptive to Princess Alice's cue on this trial, $\chi^2(2, N = 80) =$

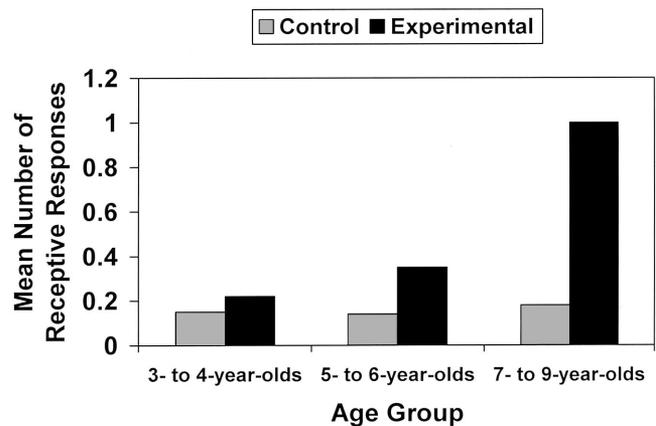


Figure 2. Verbal judgment. Age group comparison of agentive explanatory types. Percentages do not include data from the control group. "Youngest" = 3- to 4-year-olds; "middle" = 5- to 6-year-olds; "oldest" = 7- to 9-year-olds.

Table 1
Percentage of Children Whose Behavioral Responses to the Ambiguous Event (Light Turning On/Off) Matched Their Verbal Judgments^a

Overall agentive explanation	Behavioral response	
	Nonreceptive	Receptive
None (all children)	87.5%	12.5%
Youngest	95.8%	4.2%
Middle	77.8%	22.2%
Oldest	71.4%	28.6%
Intentional (all children)	80.0%	20.0%
Youngest	83.3%	16.7%
Middle	83.3%	16.7%
Oldest	50.0%	50.0%
Declarative (all children)	40.0%	60.0%
Youngest	50.0%	50.0%
Middle	60.0%	40.0%
Oldest	30.8%	69.2%

^a Experimental group only, $n = 80$.

16.08, $p < .001$ ($\Phi = .45$). A similar result was found for the iconic event trial (see Table 2), $\chi^2(2, N = 80) = 10.39$, $p < .01$ ($\Phi = .36$). Included in these tables are percentages of children in each age group whose behavioral responses to the unexpected events matched their verbal judgments.

For both categories of event, there was some degree of discordance between receptive responding and verbal judgments, with only 60% of the children who were receptive on the behavioral task providing declarative agentive explanations for the ambiguous event, and just over half (54%) the children who were receptive on the iconic event providing such verbal judgments. In addition, for the iconic event trial, children who gave nonagentive explanations were somewhat more likely (17%) to have been receptive on the behavioral task than were children who provided intentional agentive explanations (10%) for the picture of Princess Alice falling.

Discussion

The present findings suggest that, generally, children do not view ambient, unexpected events as being symbolic of communicative intentions until they are approximately 7 years of age. Only the oldest children in the study viewed such unexpected events as being about their behavior on the hiding game task. However, as revealed in their verbal judgments, the 5-year-olds were also able to detect intentional agency behind these unexpected events. But these slightly younger children failed to diagnose the communicative intent of these signs. Thus, it is not the capacity to detect agency behind unexpected events that is late-developing but the capacity to see communicative meaning in unexpected events. For events bearing an iconic relationship to the invisible agent (a picture of Princess Alice falling to the floor) as well as those having no obvious relationship to this agent (a table lamp flickering on and off), only the oldest children's behavioral responses and verbal judgments demonstrated symbolic causal reasoning.

Performance on Behavioral and Verbal Measures

In addition, performance on the two key dependent measures (i.e., receptive response and verbal judgment) was not perfectly

matched. For instance, the oldest children were somewhat more inclined to demonstrate such causal beliefs in their behaviors (82% of the oldest children were receptive to the light turning on and off or the picture falling) than in their verbal judgments (only 59% of the oldest children provided a declarative agentive explanation for these unexpected events), a trend that has also been reported in research on children's magical beliefs (Harris, Brown, Marriott, & Whittall, 1991; Subbotsky, 1997, 2001).

One speculative reason for this difference between verbal and behavioral responses is that the oldest children may simply have been more comfortable playing along with the experimenter on the behavioral task but were somewhat hesitant to state aloud that an invisible princess was trying to help them by giving them signs. With increasing age, children not only accrue more sophisticated causal knowledge through explicit teaching and their own empirical observations but also, at least in the industrialized West, they are exposed to a culture in which irrational beliefs are discouraged and often held in disrepute by authority figures (Woolley, 1997). Thus, children may become increasingly hesitant to verbally express such beliefs (even when an adult provides them with an outlet for doing so) for fear of sounding silly, this despite the fact that their cognitive systems have only recently endowed them with the capacity to see events as carrying communicative messages meant especially for them. Although the air of fantasy in the game was empirically supported by an unexpected event, a subset of the oldest children may have remained reluctant to allow a fantasy entity into the realm of reality (i.e., to "acknowledge" Princess Alice's message).

For slightly younger children ($M = 5$ years 6 months) in the experimental condition, although many (46%) stated that such unexpected events were caused by Princess Alice, they did not tend to reason that the events were about their behavior in the hiding game. This can account for these children's failure to subsequently move their hand to the opposite box earlier in the study. If the event did not connote any symbolic meaning for 5- and 6-year-olds, but was just something arbitrarily done by Princess Alice, then it should have had little effect on their behavior.

Table 2
Percentage of Children Whose Behavioral Responses to the Iconic Event (Picture of Princess Alice Falling) Matched Their Verbal Judgments^a

Overall agentive explanation	Behavioral response	
	Nonreceptive	Receptive
Nonagentive (all children)	82.6%	17.4%
Youngest	92.6%	7.4%
Middle	91.7%	8.3%
Oldest	28.6%	71.4%
Intentional (all children)	90.5%	9.5%
Youngest	75.0%	25.0%
Middle	100.0%	0%
Oldest	83.3%	16.7%
Declarative (all children)	46.2%	53.8%
Youngest	0%	100.0%
Middle	33.3%	66.7%
Oldest	55.6%	44.4%

^a Experimental group only. $n = 80$.

Indeed, among children assigned to the experimental condition, 82% of the oldest children modified their behavior to reflect a causal belief in the communicative nature of at least one of the unexpected events, whereas only 31% of children in the middle age group did so. In fact, for the iconic event, there were even fewer children in the middle age group (12%) who chose the opposite box after encountering the event than those in the youngest age group (13%) who did so (compared with 46% of children in the oldest age group who were receptive to Princess Alice's message on iconic event trials).

Finally, the youngest children ($M = 4$ years 1 month) in the study were entirely constrained to the physical causes of the unexpected events, viewing them as neither caused by the invisible agent said to be in the room nor as being about anything other than the events themselves. In other words, to these preschoolers, the picture falling was merely "the picture falling," and the light turning on and off was merely "the light turning on and off." Only 16% of the preschool-aged children in the experimental condition altered their behavior in response to the unexpected events, and an even smaller percentage (6%) gave declarative agentive verbal judgments for these occurrences. Only a few more (18%) offered intentional agentive explanations. Together, these data for the youngest children suggest that they altogether failed to tie the invisible agent concept to the unexpected events. To them, these things simply bore no causal connection.

Limitations of the Present Study

It is important to note that there was a sharp increase between ages 3 and 5 in the number of children who knew the semantic meaning of the term *invisible*. Only 26% of the youngest children could provide a correct definition (e.g., "it means you can't see her") compared with nearly all of the children in the two older age groups (76.9% of the children in the middle age group and 95.5% of the children in the oldest age group). Of course, preschoolers' lack of familiarity with a particular word does not necessarily mean that they similarly lack an understanding of the general construct to which the term refers. One (atypical) 3½-year-old who was assigned to the control condition, for instance, did provide an intentional agentive explanation when he reported that a ghost made the light flash. Also, there is some evidence that young children appreciate the causal properties of unseen entities, such as germs (Au & Romo, 1999; Siegal, 1988). Furthermore, the experimenter attempted to teach these naïve children the meaning of the word prior to the experimental session and even encouraged them to participate in an activity designed to facilitate learning of the concept ("Where do you think Princess Alice is? Do you think she's over there, or over there?" Remember, *we can't see her*"). Still, perhaps young children just have difficulty understanding the explicit concept of an invisible humanlike agent. For example, preschoolers may understand *invisible* to simply mean too small to be seen (Taylor, 1999).

One way to empirically address this issue would be to ask children to have a "dialogue" with Princess Alice in the context of their introduction to the invisible agent such that she actively responds to the child's comments through an unexpected event (e.g., the light flashing). This manipulation would be somewhat similar to that used by Johnson, Booth, and O'Hearn (2001), who demonstrated that 15-month-old infants use contingency cues (an

object "waving" at the infant in response to the infant's gestures or vocalizations) to demarcate intentional, goal-driven agents from inanimate objects (see also Legerstee, 1997). In the present context, such contingency cues should serve to give children familiarity with the invisible agent's mode of communication (e.g., an ambient physical event) and also to offer apparent confirmation of her presence in the room. Then, during the actual experiment, the same unexpected event or a novel unexpected event (e.g., the picture falling) occurs contingent with the child's response. If young children in fact possess the capacity to view unexpected events as personally communicative devices, but simply require firsthand, contingent experience with the supernatural figure prior to the actual experiment, then they should at least demonstrate a receptive response to the familiar unexpected event.

Another limitation of the present study is that it is unclear whether the 3- and 5-year-olds' performance would have been different (i.e., more receptive responding) had Princess Alice had a more tangible physical presence in the room. A key follow-up study would therefore involve a similar methodology but would compare—through a counterbalanced within-subjects design—children's receptive responding to unexpected events "caused" by an invisible Princess Alice with those "caused" by a visible Princess Alice. There may be important developmental milestones in this domain of causal reasoning that involve stages of supernatural agent representation. Younger children may indeed possess the capacity to see communicative meaning in unexpected events but must hang these causal attributions on an actual physical agent in the environment who is deemed to have supernatural powers (e.g., Santa Claus, the tooth fairy, and other culturally postulated supernatural agents endowed with solid bodies). Perhaps it is only later in development that children are able to make such attributions to abstract entities.

Finally, the fact that the oldest children who were assigned to the control group failed to respond receptively to the unexpected events suggests that conceptual primes involving a supernatural agent are meaningfully involved in this form of causal reasoning. In other words, these data seem to show that children do not spontaneously see "signs" in unexpected events but instead require some degree of priming associated with a specific supernatural agent concept. However, these findings may simply be an artifact of the laboratory environment—perhaps ascriptions of meaning do occur in the real world with minimal conceptual priming. Furthermore, precisely how such primes are involved, and whether adults are similarly dependent on supernatural primes (e.g., through frequent church attendance, rumination on a recently deceased loved one, and so forth) at this point remains unclear.

Interpretation of Age Group Differences

In our view, however, the most striking findings from the present study involve the contrast between the 5- and 7-year-olds in the experimental group because the former clearly understood the concept of the invisible agent. (Recall that in their verbal judgments, the 5-year-olds reasoned that Princess Alice caused the unexpected events.) One speculative interpretation of these age group differences is that in order to be receptive to such supernatural signs, a child must possess a second-order theory of mind (Bering & Johnson, 2005; see also Dunbar, 2003). To reason in this fashion requires that the epistemic states of the other agent and

the self be recursively represented ("As she can see from my behavior, Princess Alice knows [I don't know] where the ball is actually hidden; thus, that event is her informing me that I have a false belief"). Prior to achieving a second-order understanding of mental states, children may see the event as being intentionally caused by an abstract agent but not understand the declarative or referential nature of the event.

This is indeed how children in the middle age group responded. The present data are also in line with previous findings showing that the ability to engage in such mental state recursiveness is first reliably demonstrated in the early grade school years, at about age 7 (Astington, Pelletier, & Homer, 2002; Perner & Wimmer, 1985; for an exception, see Sullivan, Zaitchik, & Tager-Flusberg, 1994). Clearly, future research that draws on the present design should include a second-order task in order to determine whether successful performance is correlated with children's causal reasoning about unexpected events.

In a similar vein, another characteristic of the present task that made it different from previous studies was that children responded before they were presented with the communicative sign. They were then allowed time (15 s) to change their response after receiving the sign. This gave children the opportunity to exhibit their (false) belief about the location of the hidden object so that the knowledgeable partner could, if necessary, give corrective feedback regarding their present behavior. Unlike previous studies that have reported evidence of referential and declarative understanding in much younger children (e.g., Caron et al., 2001; Povinelli et al., 1997; Tomasello et al., 1997), the communicative sign in the present study was not about the location of the hidden object, per se, but was instead about how the self's own actions were being perceived by the knowledgeable partner. The unexpected events therefore served as corrective declaratives rather than the standard declaratives used in previous hiding game tasks. If translated to a conventional laboratory procedure using eye gaze or indexical pointing, then an understanding of such corrective declaratives may prove difficult for young children who otherwise pass the standard declarative task.

Conclusion

The present findings help to identify the developmental trajectory of children's capacity to see meaning in unexpected events. However, the specific cognitive mechanisms involved have yet to be identified. It is also presently unclear whether the tendency for people to go beyond veridical causal explanations serves a biologically adaptive function. Is there a genetic advantage associated with this cognitive profile, perhaps linked to human social evolution or children's acquisition of moral rules (Bering, in press)? Or, is this tendency simply a curious, but functionless, extension of human intentionality (Atran & Norenzayan, 2004; Barrett, 2000; Boyer, 2001)? Future work in this area should strive to shed additional light on this common, but empirically neglected, explanatory system—one which seemingly leads people to infer meaning in events in which, in reality, there may be no meaning at all.

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Appendix

General Coding Guidelines and Examples of Explanatory Types for Posttest Interview Sessions

No explanation: The child either remained silent or otherwise did not volunteer a verbal judgment (e.g., shrugs shoulder), stated “I don’t know” in response to the experimenter’s questions or made a nonarticulate, unscorable response.

Physical: The child stated that the event occurred because of a mechanistic or physical fault, such as the light being broken or the magnet on the picture not being strong enough to hold the picture; alternatively, the child provided a mechanistic explanation, such as reasoning that there must be a sensor on the light:

Because I hit this [box] too hard and it made the light go on. (7 years 2 months; ambiguous event).

I bet there’s a sensor in there, or under the table, so that if you snap, it’ll sense. Because nobody’s in the room, and there’s no other access to the light. (7 years 3 months; ambiguous event).

Because it [the picture of Princess Alice] wasn’t sticking very well. (4 years 8 months; iconic event).

Because there was tape on the thing and it probably fell off. (7 years 4 months; iconic event).

Other person: The child stated that the event was caused by a person other than Princess Alice, such as the experimenter, the child’s mother, or a person in a different room:

Someone turned the lights off and on. I think my mom. I think strangers did it. Ok, a stranger did it. (5 years 1 month; ambiguous event).

Because someone banged on the door. (7 years 11 months; iconic event).

Animistic: The child stated that the object(s) involved in the event intentionally caused their occurrence^a:

Because it turned off and on and off and on because it wanted to. (3 years 1 month; ambiguous event).

Because it wanted to, because it wanted to fall. (same child as in foregoing example; iconic event).

Intentional agentive: The child stated that Princess Alice caused the event, either mentioning her by name or pointing to the picture and using the term ‘she,’ but upon follow-up questioning stated that they did not know why she caused the event, or stated that she ‘liked it like that’ or ‘just wanted to.’

Princess Alice did it [made the picture fall]. Why do you think she did it? [Child shrugs her shoulders.] Any idea why she did it? [Child shakes her head.] (5 years 4 months; iconic event).

Princess Alice took it off. ‘Why did she do that?’ She thought it would look better in another place. (5 years 4 months; iconic event).

Declarative agentive: The child either (a) stated that Princess Alice caused the event and that she did so in order to help them find the ball, telling them that they had their hand on the wrong box; or (b) stated that the event occurred because they had chosen the wrong box (because each unexpected event occurred only once in order to prevent association learning, was counterbalanced across trials, and children were rewarded with the prize on control trials even when moving their hand to the box opposite from where it was originally placed, we believe that this “because I chose the wrong box” explanation can only be understood as declarative agentive).

Because she [points to Princess Alice] was telling me it was the wrong one. (7 years 4 months; ambiguous event).

It’s another way of her [after attributing the picture falling to Princess Alice] not speaking, so she doesn’t have to talk to tell me that it’s wrong. (7 years 6 months; ambiguous event).

Because I chose the wrong box—because I don’t want to see her (5 years 1 month; iconic event).

^aThere were only 3 children (1 in each age group) out of the 151 participants who provided animistic verbal judgments.

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