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The Development of Preschoolers' Appreciation of Communicative Ambiguity

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Using a longitudinal design, preschoolers' appreciation of a listener's knowledge of the location of a hidden sticker after the listener was provided with an ambiguous or unambiguous description was assessed. Preschoolers (N = 34) were tested at 3 time points, each 6 months apart (4, 4½, and 5 years). Eye gaze measures demonstrated that preschoolers were sensitive to communicative ambiguity, even when the situation was unambiguous from their perspective. Preschoolers' explicit evaluations of ambiguity were characterized by an initial appreciation of message *clarity* followed by an appreciation of message *ambiguity*. Children's inhibitory control skills at 4 years old related to their explicit detection of ambiguity at later ages. Results are discussed in terms of the developmental progression of preschoolers' awareness of communicative ambiguity.

Our language system is inherently ambiguous in that the same phrase can be interpreted differently depending on the contextual backdrop. For example, the phrase ''Nice job'' would be considered a literal compliment if the recipient of the message had excelled on an exam but would be considered as an ironic criticism if the recipient had failed the exam. Furthermore, any given statement can be more or less *successful* depending on the context in which it is uttered. For example, the question ''Can you pass me the pen on my desk?'' is unambiguous if there is only one pen on your desk, but is ambiguous if there are several pens present. These examples highlight a critical aspect of communicative competence, namely, the ability to appreciate when communicative ambiguity has occurred. This ability involves assessing both what is communicated linguistically and what can be inferred via nonlinguistic information. Thus, detecting ambiguity requires tracking the information that is part of contextual backdrop, monitoring the knowledge state of one's conversational partner, and integrating these sources of information with the linguistic input. The goal of this study was to chart the developmental course of preschoolers' ability to detect referential ambiguity between 4 and 5 years of age. Using a longitudinal design, we assessed the development of preschoolers' appreciation of the knowledge shared between speakers and listeners when judging the clarity or ambiguity of linguistic messages for another person.

Much research has demonstrated that early school-age children often do not detect communicative ambiguity. That is, they will overestimate their knowledge after being presented with ambiguous instructions and will make decisions based on inadequate information (e.g., Beck & Robinson, 2001; Beck, Robinson, & Freeth, 2008; Flavell, Speer, Green, August, & Whitehurst, 1981; Ironsmith & Whitehurst, 1978; Robinson & Robinson, 1982, 1983). There is, however, other evidence to suggest that children's sensitivity to communicative ambiguity emerges during the preschool years. When asked to act on a message that varies in referential clarity, children as young as 3.5 years appreciate that a referring expression is ambiguous (e.g., Plumert, 1996; Revelle, Wellman, & Karabenick, 1985) and show nonverbal behavior that reflects hesitancy to act (Patterson, Cosgrove, & O'Brien, 1980). Similarly, when asked to produce a message for a conversational partner, children as young as 3

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will vary the production of their message to avoid ambiguity (Matthews, Lieven, Theakston, & Tomasello, 2006; Nadig & Sedivy, 2002; Nilsen & Graham, 2009; O'Neill, 1996). In one study, Nilsen and Graham (2009) presented 4- and 5-year-olds with a communicative task that required they identify a particular object within a display of four objects for an adult listener. Children were more likely to provide an adjective to describe the target object when there were two similar objects (i.e., two cups) that the listener could see in the display versus when one member of the object pair was blocked from the listener's view. This demonstrates that preschoolers differentiate between information that is accessible to their conversational partner versus to themselves and will vary their message to avoid ambiguity.

In contrast to the previous findings, when asked to evaluate the referential clarity of a message from third-person perspective, many studies have demonstrated that children under 6 years of age have difficulty in judging speaker success (Singer & Flavell, 1981). For example, Robinson and Robinson (1977) found that 6-year-olds often judged ambiguous messages as sufficient and were more likely to blame the listener for miscomprehension following an ambiguous message rather than the speaker. This difficulty is magnified when the child is aware of the intended meaning of the message (Beal & Belgrad, 1990; Beal & Flavell, 1984). For example, when 4-year-olds were aware of the intended meaning of an ambiguous message regarding the location of some hidden chocolate (i.e., they knew where it was hidden), they overestimated the informativeness of the message for a naive listener. It was not until children were 6 years old that they put aside their privileged knowledge to indicate that an ambiguous message would be ineffective in helping the listener to find the chocolate (Sodian, 1988).

Why might children have more difficulty in evaluating messages directed toward a third person than evaluating messages directed to themselves? Clearly, third-person ambiguity detection tasks are conceptually more difficult; children need to distinguish their own knowledge from that of the listener, recognize that the ambiguous message does not offer sufficient information to the native listener, and then make an explicit evaluation of the linguistic description. Thus, this type of task requires children to overcome a pervasive social bias that leads them to be ''cursed'' by their own knowledge when making judgments from the perspective of a more naive individual (Birch, 2005; Birch & Bloom, 2007). More specifically, in order to appreciate ambiguity from a less knowledgeable perspective than their own, children must inhibit their knowledge of the intended meaning. This suggests that if children lack the inhibitory control to suppress their perspective, they will fail to appreciate the ambiguity in the utterance.

In addition to the added conceptual difficulty posed by third-person tasks, it is possible that the methods used in previous studies have underestimated children's ability in such tasks. That is, studies have typically employed paradigms that ask children to determine whether a listener would be successful in determining the appropriate referent after hearing a description, or require children to indicate whether a speaker did a good job at describing something. Indeed, when preschoolers' ambiguity detection skills are assessed via more sensitive measures such as response latencies or eye movements, children as young as 4 years of age show early signs of sensitivity to message ambiguity from a third-party perspective (Bearison & Levey, 1977; Flavell et al., 1981). For example, Nilsen, Graham, Smith, and Chambers (2008) recently compared 4-year-olds' explicit detection of ambiguity (as indicated by their pointing behavior) with their implicit sensitivity to ambiguity (as indicated by response latencies and gaze duration measures). Preschoolers were asked to assess another person's knowledge of the location of a hidden sticker after that person heard either an ambiguous or an unambiguous description of the sticker location. Preschoolers looked longer toward referential alternatives after hearing an ambiguous clue directed at a listener, even when they were provided with privileged information that would disambiguate the statement. Despite the fact that children looked at both referents, suggesting that they appreciated that the message could refer to either option, they did not explicitly indicate that a message was ambiguous. These results suggest that an implicit sensitivity to ambiguity in messages directed toward others emerges during the preschool years.

Distinguishing between the role of implicit and explicit levels of processing in developmental achievements has critical theoretical and empirical implications and has been investigated in areas such as false-belief understanding (Clements & Perner, 1994; Garnham & Ruffman, 2001), strategies for problem solving (Goldin-Meadow, 2003; Siegler, 2000), and executive functioning (Ahmed & Ruffman, 1998). Indeed, it has been argued that many of children's cognitive abilities initially develop in an implicit form and become explicit over time (Karmiloff-Smith, 1992). For example, children's eye movements reveal an earlier sensitivity to false belief than explicit responses, suggesting that the ability to *represent a situation* emerges before the ability to *make a judgment about a situation* (Clements & Perner, 1994). Accordingly, implicit sensitivity may serve a function in helping children to develop later explicit awareness. Goldin-Meadow and colleagues propose that implicit ''insight'' marks a transitional stage in which children are ready to make maximal use of conceptual instruction. To test the transitional stage hypothesis, Clements, Rustin, and McCallum (2000) trained children between the ages of 2 and 5 years on false-belief tasks. Children who showed anticipatory looking to the correct location, indicative of implicit sensitivity, benefitted from training whereas the children who did not demonstrate implicit sensitivity did not show such gains. Thus, implicit measures reflect a more accessible representation that later, with instruction, becomes explicit.

In the present research, we pursued the examination of preschoolers' detection of ambiguity in messages directed toward others with particular focus on the following questions: First, is the implicit sensitivity to ambiguity shown by the preschool children in previous studies a precursor to the correct explicit judgments observed with 6- to 8-year-olds (e.g., Beal & Belgrad, 1990; Sodian, 1988)? Related, is there a developmental projection in terms of children's message evaluation skills whereby children first evidence implicit sensitivity to ambiguity, followed by behavior indicative of ambiguity detection, and later explicit understanding of communicative ambiguity? Second, do specific cognitive skills contribute to preschoolers' developmental progression from implicit sensitivity to the ability to make explicit judgments about message ambiguity?

We used a longitudinal design to investigate these questions, testing children at three ages: 4, 4½, and 5 years. At each assessment, children were administered a message evaluation task in which they were asked to assess the clarity of messages regarding the location of a hidden sticker provided to an adult listener. Across trials, half of the messages provided to the listener unambiguously identified the location of the sticker (e.g., ''It's under the red cup''; when there was a small red cup and a small blue cup in the display) whereas the other half did not clearly identify the location of the hidden sticker (e.g., ''It's under the small cup''). In order to assess whether children would conflate their own knowledge with that of the listener, children's knowledge of the intended meaning of the message (i.e., the sticker location) was varied across trials. That is, on half of the trials, children knew where the sticker was hidden, and on the other half of the trials, they were unaware of where the sticker was hidden. Both implicit measures of children's sensitivity to ambiguity (e.g., eye gaze duration) and explicit detection and understanding (e.g., pointing behavior, overt judgments of a clue being ''good'' or ''tricky'') were used. The explicit measures draw upon controlled and intentional processes that reflect *detection* or *understanding* of message ambiguity, whereas the implicit measures draw upon processes that are less controlled, have no intentions, have little understanding of meaning, but nonetheless demonstrate *sensitivity* to message ambiguity (Bargh, 1994; Nosek, 2007).

We predicted that preschoolers' implicit sensitivity to ambiguity would occur at an earlier developmental point than their explicit judgments of ambiguity. That is, we expected that children would show implicit sensitivity to message ambiguity at 4 years of age, as indexed by their eye movement data, but would not evidence sensitivity through their overt behavior (i.e., pointing) until 4½ years of age. Based on previous work (e.g., Beal & Belgrad, 1990), we expected that children's explicit understanding of message ambiguity, as indexed by their message evaluations, would start to emerge around their fifth birthday. The use of a longitudinal design also allowed us to assess the degree to which early implicit insights would be related to children's later explicit declarations of message ambiguity. According to the transitional hypothesis, implicit sensitivities allow children to demonstrate later explicit successes (Clements et al., 2000). Within theory of mind development, implicit awareness operates at an earlier stage and serves a function in *helping* children to develop later explicit awareness. Thus, it may be that early implicit sensitivity to communicative ambiguity facilitates the growth of explicit ambiguity detection skills. However, given that children are not aware of the knowledge conveyed through their eye gaze (e.g., Ruffman, Garnham, Import, & Connolly, 2001), it is also possible that early implicit sensitivity does not relate to later explicit understanding, but rather that other skills play more of a facilitative role in the explicit understanding of ambiguity.

To address the possibility that specific cognitive skills play a role in children's ability to detect ambiguity, we assessed children's inhibitory control skills at the three assessment periods. We predicted that inhibitory control skills may play a role in the development of ambiguity detection in messages directed to others as children are required to take the perspective of another and monitor the ambiguity of the message from that perspective. Inhibitory control has been implicated in children's ability (or, more accurately, their difficulty) in ignoring privileged information (e.g., Birch, 2005; Birch & Bloom, 2003; Friedman & Leslie, 2004). Thus, we posited that inhibitory control skills would be particularly relevant on trials where children have been given privileged information about the intended meaning of the messages. On those trials, children must suppress their own perspective in order to take the perspective of a naïve listener. Indeed, recent research has demonstrated that inhibitory control contributed to preschoolers' ability to engage in communicative-perspective-taking tasks (Nilsen & Graham, 2009). Here, we predicted that children who demonstrated more proficient inhibitory control skills would be more likely to indicate that an ambiguous clue was indeed unclear, especially when they were previously shown where the speaker had hidden the sticker.

Method

Participants

The original sample consisted of forty-nine 4-year-olds. Ten children did not continue with the study after the first testing session, and 5 did not continue after the second session, resulting in a final sample of 34 children who participated in all three testing sessions (16 males, 18 females). Children who did not complete all the three testing sessions did not differ from children who did complete all sessions on any of the independent or dependent variables used in the study as assessed at the first time point, all $ps > .42$.

Children were 4 years old at the first testing session (4 years old: $M = 49.1$ months, range = 47.5–52.8 months), and were assessed at 6-month intervals (4½ years old: $M = 55.1$, range = 52.9–56.5 months; 5 years old: $M = 61.3$, range = 59.4–62.7). Children were recruited from health clinics and trade shows in a large metropolitan area. Participants were primarily Caucasian (94%) from socioeconomic backgrounds that varied within the more general middle-class level, and were from homes in which English was the primary language spoken.

Materials

A wooden case was designed to display a pair of objects on opposing corner shelves (see Appendix A). A digital camcorder was located inside the display case, aimed toward the participant's face. A moveable curtain was attached at the front of the display case and was rotated to obscure the objects from the perspective of the second experimenter (E2), or from the perspectives of both E2 and the child. Twelve pairs of familiar objects differing in either size or color were used in the task (e.g., a small and big teddy bear, a red and blue cup; see Appendix B, Table B1 for a complete listing).

Procedure

Children were assessed three times on their ability to detect ambiguity in a message evaluation task, as well as on their language and inhibitory control skills: first, when they were approximately 4 years old; second, when they were approximately 4½ years old; and third, when they were approximately 5 years old. The interval between each assessment period was approximately 6 months. Testing at each assessment period was conducted in two sessions, with the second session occurring within a week of the first session. The message evaluation task was always presented during the first session. The inhibitory control tasks and the language measure were administered in a counterbalanced order during the second session. Children were individually tested by two experimenters in a quiet room in a laboratory.

Message Evaluation Task

The child and the second experimenter (E2) sat at a table facing the display case with the first experimenter (E1) seated across the table holding "Spot," a dog puppet, behind the display case. The task began with a demonstration that emphasized that E2 could not see objects placed on the display case when the curtain was partially closed. After the demonstration concluded, children were told that a sticker would be hidden on each test trial and that Spot would give E2 a clue regarding the sticker's location.

Each test trial took the following form: First, E1 placed the curtain in the appropriate position based on the condition and placed a pair of objects in opposing corners on the display case. The objects were always identical except for one salient property (size or color). E1 hid a sticker beneath one of the objects and then moved the curtain to allow E2 full visual access to the objects. Using the puppet, a clue was provided to E2 regarding the location of the sticker. The child then was asked to indicate where E2 thinks the sticker is by pointing to an object on the display case (i.e., "When Spot gives

[E2] the clue, you point to where [E2] thinks it is. Here's Spot's clue for [E2]''). This pointing measure allowed us to assess children's overt behavioral *detection* of ambiguity. That is, if children pointed to objects at chance levels, this would suggest that they appreciate the clue could refer to either object. However, if the children's points toward an object differed from chance, this would suggest that they appreciated that the clue refers to a particular object. During this task, children's eye movements were recorded to assess the degree to which they were implicitly *sensitive to* communicative ambiguity. Specifically, if children gazed at both objects equally, this would suggest that they considered either object as a possible referent for the clue. Following the child's response, E1 then asked the child about the adequacy of the clue (e.g., ''When Spot told [E2] the sticker was 'under the blue cup' was that a good clue or a tricky clue?''). Children's explicit message evaluations allowed for an examination of their *understanding* of communicative ambiguity. That is, this measure assesses the degree to which children understand that an ambiguous message is unclear to the listener. In order to facilitate children's responses, they were asked to indicate their decision regarding the adequacy of the clue by placing buttons in boxes that provided visual cues (i.e., boxes that depicted a happy face for a good clue and a confused face for the tricky clues). The placement of the *good* and *tricky* boxes, as well as the order in which those adjectives were presented within the question, was counterbalanced across trials. To ensure that children understood the meaning of the word *tricky*, a control question was asked at each testing session (i.e., ''Does 'tricky' mean 'good' or 'not so good'''?).

Two experimental parameters were varied across 12 trials: the child's knowledge and the message quality. See Appendix B, Table B2 for an overview of the four conditions. First, the child's knowledge of where the sticker was hidden was varied as a function of the position of the curtain on the apparatus. When the child was *knowledgeable*, the curtain was positioned so that the objects were visible to the child while the sticker was concealed. When the child was *unknowledgeable*, the curtain was fully closed so that the child was not privy to where the sticker was hidden. E2 was never given visual access to the contents of the display case during the sticker-hiding process. At specific times during the 12 trials, children were asked questions about the task to reinforce this manipulation. That is, children were asked on four occasions whether E2 could see where the sticker was hidden as well as whether Spot could see where the sticker was hidden with corrective feedback. Children answered these questions correctly between 84% (Time 1), 93% (Time 2), and 97% (Time 3) of the time. Second, message quality was manipulated such that the clue given by the puppet was either *ambiguous* (e.g., ''It's under the *small cup*,'' when the object pair was a small red cup and a small blue cup) or *unambiguous* from E2's perspective (e.g., ''It's under the *small bear*,'' when the object pair was two differently sized black bears). On half of the trials, the clue provided was ambiguous, and on the other half, it was unambiguous. These variations results in trials in four within-subjects conditions: knowledgeable–ambiguous, knowledgeable–unambiguous, unknowledgeable–ambiguous, and unknowledgeable–unambiguous. There were three test trials in each of these four conditions, presented in a counterbalanced order in a blocked fashion.

The various display objects were designated as either the target object or the referential alternative for each trial. The target object was the object under which the sticker was hidden. It was uniquely identified when the message was unambiguous. The referential alternative was the other member of the object pair—when the message was ambiguous, it could refer to either the target object or the referential alternative. For example, when the cup pair was presented in the display, the ambiguous statement ''It's under the *small cup*,'' could refer to the target object (the red cup) or the referential alternative (the blue cup). In contrast, the unambiguous statement, ''It's under the *red cup*'' could only refer to the target object. Which object was the target object and which was the referential alternative for each object pair was counterbalanced across children.

Children's eye movements during the task were analyzed by coders who were unaware of the experimental hypotheses. The digital video record was examined on a frame-by-frame basis (33 ms) using FinalCut Pro 5.0.4 (Apple, Cupertino, CA), with audio and video signals fully synchronized. For each trial, children's fixations to display objects were coded from the start of the clue adjective (e.g., the ''/b/'' sound of ''blue'' in the statement, ''It's under the ''blue'' cup'') to the initiation of their pointing gesture (i.e., the lifting of the shoulders as indicative of a point). The coders were unaware of which object was the target object and which object was the referential alternative due to the positioning of the camera. Six randomly chosen participants at each assessment period were coded a second time (18% of the sample) to provide a measure of interrater reliability of the eye movement data.

Intraclass correlation coefficients (ICCs) were used to establish the level of agreement between coders as these statistics assess both the pattern of agreement and the level of agreement of raters (Sattler, 1992). ICC coefficients for the durations of looking time toward the target objects and referential alternatives at each time point ranged from ICC (141) .92 to .96, *p*s < .001.

Inhibitory Control Tasks

The children were assessed on two Stroop-like inhibitory control tasks, *day–night* (Gerstadt, Hong, & Diamond, 1994) and *grass–snow* (Carlson & Moses, 2001). Both tasks examine children's ''conflict'' inhibitory control in that children were required to suppress a salient response and generate a novel response (Carlson & Moses, 2001), as opposed to purely delaying their response. This type of inhibitory control was assessed as it is more commonly associated with children's ability to infer the mental states of others than ''delay'' inhibition tasks (e.g., Carlson & Moses, 2001; Hala, Hug, & Henderson, 2003). In the day–night task, children were first asked questions about what is in the sky at night (i.e., stars) and what is in the sky during the day (i.e., the sun). They were then presented with a card depicting a sun in a light blue sky and another card showing a dark night sky with stars and a moon. They were instructed to say ''day'' when they were presented with the stars and moon card and ''night'' when they were presented with the sun card. After three practice trials with corrective feedback, children were administered 16 trials in a preset pseudorandom order. Children were not provided with feedback on the test trials. Children's accuracy score (out of 16) was recorded.

In the grass–snow task, children were asked to name the color of grass (i.e., green) and the color of snow (i.e., white). They were then shown two cards (one white, one green) displayed side by side (green on the left, white on the right) on a vertical board. Children were told that whenever the experimenter said ''grass'' they were to point to the white card, and whenever the experimenter said ''snow,'' they were to point to the green card. Following three practice trials with feedback, children were administered the 16 test trials. Accuracy (out of 16) was recorded as the unit of analysis.

Language Task

In order to obtain a measure of receptive language skills, children were administered the Peabody Picture Vocabulary Test–Third Edition (PPVT–III; Dunn & Dunn, 1997). This test was administered in a standardized fashion. The number of correct items was included as the measure of language skills in the statistical analysis.

Results

Recall that our primary research questions were: (a) What is the developmental progression of children's implicit and explicit detection of message ambiguity? (b) What is the relation between implicit and explicit measures of ambiguity detection? and (c) Are children's inhibition skills related to their ability to suppress their own knowledge to appreciate ambiguity from a third person perspective? The analyses conducted to address each of these questions are discussed in order next.

When Do Children Implicitly and Explicitly Detect Message Ambiguity?

To address this research question, we analyzed children's performance using implicit and explicit measures taken during two phases of the message evaluation task. Recall that in the message evaluation task, children first were asked to point to where they thought the recipient of the clue would think the sticker was hidden, and second, they were asked to indicate whether the clue provided was ''good'' or ''tricky.'' In the first phase, the implicit measure used was the duration of looking time toward the display objects (i.e., the target object and the referential alternative)—and the explicit measure was the object to which children pointed. In the second phase of the task, the explicit measure was the children's actual response to the message evaluation question (i.e., ''good'' or ''tricky''). Each dependent variable was subjected to a 2 (knowledge state: knowledgeable vs. unknowledgeable) × 2 (message quality: unambiguous vs. ambiguous) × 3 (age at testing: 4, 4½, and 5 years) repeated measures analysis of variance (ANOVA). Significant interactions were followed with paired-samples *t* tests with Bonferroni corrections (i.e., .05/number of comparisons). In addition, where appropriate, children's scores were compared with chance-level responding.

Phase 1: Determining Where the Listener Will Think the Sticker Is Hidden

When children were asked where the listener would think that sticker was hidden (i.e., the first phase of the task), the variables of interest focused on children's behavior toward the referential alternative. Recall that if a message was ambiguous, it could refer to either the referential alternative or the target object. In contrast, if a message was unambiguous, it would refer only to the target object. Thus, any behavior that the child directed toward the referential alternative reflected recognition that the message could refer to either object.

Implicit Measure: Number and Duration of Fixations

The number and duration of fixations children made on each object on the display was calculated. The number of fixations provides an assessment of where children's attention is drawn during online processing, whereas duration assesses how long children attend to the different objects. The number and duration of fixations to the referential alternative relative to the total frequency and time spent fixating both the target object and the referential alternative were calculated for each condition (see Table 1). These proportional measures were used instead of raw fixation durations to control for the possibility that inflated looking frequency and time to an object in a given condition may mask an outcome where fixations to all display items were greater in that condition.

Number of fixations. An ANOVA revealed significant main effects of knowledge state, $F(1, 32) = 24.27$, $\eta_p^2 = .43$, $p < .001$, and message quality, $F(1, 32) = 51.01$, $\eta_p^2 = .61$, $p < .001$. There was no main effect of age at testing ($p = .19$) or any significant interactions (ps > .1). Children looked at referential alternative proportionately more often when they were unaware of the sticker location ($M = 0.45$, $SD = 0.08$) than when they were aware of the location ($M = 0.36$, $SD = 0.06$). The main effect of message quality indicated that children looked at the referential alternative proportionately more often when the clue was ambiguous ($M = 0.47$, $SD = 0.05$) versus when the clue was unambiguous ($M = 0.35$, $SD = 0.09$).

Children's proportions of fixations to the referential alternative were compared with chance (.5) using one-sample t tests. Following unambiguous messages, children fixated on the referential alternative less often than would be expected by chance across the three time periods, regardless of their knowledge state, ts(33) = 12.32 and 4.30, respectively, for knowledgeable and unknowledgeable conditions, ps < .001. Following ambiguous messages, children fixated on the referential alternative at chance levels when unknowledgeable ($p = .24$) but below chance levels when aware of the intended location, $t(33) = 5.87$, $p < .001$, across the three assessment periods.

Duration of fixations. Consistent with the previous analyses, an ANOVA yielded a significant main effect of knowledge state, $F(1, 32) = 4.72$, $\eta_p^2 = .13$, $p < .05$ and a main effect of message quality, $F(1, 32) = 144.33$, $\eta_p^2 = .82$, $p < .001$, but no main effect

Table 1
Means (Standard Deviations) of Implicit and Explicit Dependent Variables as a Function of Condition

	Ambiguous message		Unambiguous message	
	Knowledgeable child	Unknowledgeable child	Knowledgeable child	Unknowledgeable child
Where will the experimenter think the sticker is?				
Proportion of fixations to referential alternative				
Time 1 (4 years old)	0.44 (0.10)	0.54 (0.07)	0.28 (0.12)	0.43 (0.23)
Time 2 (4½ years old)	0.43 (0.14)	0.48 (0.07)	0.31 (0.12)	0.33 (0.20)
Time 3 (5 years old)	0.43 (0.10)	0.50 (0.10)	0.31 (0.21)	0.42 (0.33)
Across ages	0.43 (0.07)	0.51 (0.06)	0.30 (0.10)	0.39 (0.14)
Proportion of fixation duration to referential alternative				
Time 1 (4 years old)	0.45 (0.14)	0.52 (0.09)	0.24 (0.16)	0.32 (0.15)
Time 2 (4½ years old)	0.45 (0.15)	0.46 (0.10)	0.29 (0.16)	0.26 (0.16)
Time 3 (5 years old)	0.42 (0.10)	0.49 (0.11)	0.27 (0.21)	0.26 (0.14)
Across ages	0.44 (0.07)	0.49 (0.05)	0.27 (0.11)	0.28 (0.09)
Proportion of points to referential alternative				
Time 1 (4 years old)	0.30 (0.37)	0.57 (0.29)	0.06 (0.19)	0.10 (0.19)
Time 2 (4½ years old)	0.30 (0.36)	0.55 (0.28)	0.07 (0.17)	0.03 (0.13)
Time 3 (5 years old)	0.20 (0.29)	0.47 (0.31)	0.08 (0.18)	0.07 (0.16)
Across ages	0.27 (0.19)	0.52 (0.16)	0.07 (0.11)	0.07 (0.10)

of age at testing, $p = .27$, or any significant interactions, ps > .07. The main effect of knowledge state indicated that children looked longer at the referential alternative when they were unaware of the sticker location ($M = 0.38$, $SD = 0.05$) than when they were aware of the location ($M = 0.35$, $SD = 0.07$). Importantly, the main effect of message quality indicated that children's responses reflected sensitivity to message ambiguity in that they looked longer at the referential alternative when the clue was ambiguous ($M = 0.47$, $SD = 0.05$) versus when the clue was unambiguous ($M = 0.27$, $SD = 0.08$).

We compared children's proportion of looking duration at the referential alternative with levels expected by chance (i.e., .5) using one-sample t tests. After hearing unambiguous messages, children's duration of fixations toward the referential alternative were at less than chance levels when both knowledgeable and unknowledgeable, at all three assessment periods, ts(33) = 12.60 and 14.28, respectively, ps < .001. Following ambiguous messages, children looked at the referential alternative at chance levels when unknowledgeable ($p = .29$) but below chance levels when aware of the intended location, $t(33) = .4.74$, $p < .001$, across the three assessment periods. Thus, children's knowledge did impact their eye gaze following ambiguous clues.

Together, the results of eye gaze analyses indicate that children showed an implicit sensitivity to ambiguity as they looked more often and proportionately longer at the referential alternative after hearing an ambiguous message versus an unambiguous message. Their knowledge did affect their fixation duration and number in that they considered the referential alternative less often and for proportionately less time when they were aware of the sticker location, but this did not vary with message quality. This implicit sensitivity to ambiguity did not vary with age at assessment.

Explicit Measure: Pointing Behaviors

Children's pointing behaviors reflected the extent to which their overt behavior reflected detection of communicative ambiguity. If children detected the ambiguity of messages, they would point to the referential alternative and target object equally following ambiguous messages but not following clear messages. Note that in the case of ambiguous messages, there is no clear ''correct'' answer. As such, inferences about children's detection of ambiguity are made through children's pattern of responding across the trials.

An ANOVA on children's pointing to the referential alternative yielded a main effect of knowledge state, $F(1, 32) = 60.43$, $\eta_p^2 = .65$, $p < .001$, and a main effect of message quality, $F(1, 32) = 165.55$, $\eta_p^2 = .84$, $p < .001$, but no main effect of age at testing, $p > .28$. There was a significant interaction between knowledge state and message quality, $F(1, 32) = 42.43$, $\eta_p^2 = .57$, $p < .001$. The interaction was followed up with comparisons collapsed across age at testing. When children heard an unambiguous message, they pointed to the referential alternative to a similar extent when knowledgeable ($M = 0.07$, $SD = 0.11$) or unknowledgeable ($M = 0.07$, $SD = 0.10$), $p = .85$. In contrast, when children heard an ambiguous statement, they were more likely to point to the referential alternative when they were unaware of the sticker location ($M = 0.52$, $SD = 0.16$) compared to when they were knowledgeable ($M = 0.27$, $SD = 0.19$), $t(32) = 8.04$, $d = 1.42$, $p < .001$. Importantly, even when knowledgeable, children were more likely to point to the referential alternative following an ambiguous message than following an unambiguous message, $t(33) = 5.77$, $d = 1.29$, $p < .001$. Thus, children's pointing provides evidence of their detection of ambiguity in messages; however, their knowledge of the location of the sticker continued to influence their pointing following ambiguous messages.

In the final analyses in this set, we compared preschoolers' pointing responses to the referential alternative to the levels expected by chance (i.e., .5) using one-sample t tests. Children's pointing at the referential alternative after hearing an unambiguous message were consistently below chance levels across the ages at testing, for both knowledge states, ts(33) = 22.98 and 25.58, ps < .001 for knowledgeable and unknowledgeable conditions, respectively. At all three assessment periods, preschoolers pointed to the referential alternative at chance levels after hearing an ambiguous message when unaware of the location of the sticker, $p > .28$. However, when aware of the location of the sticker, they pointed to the referential alternative fewer times than expected by chance following an ambiguous message, ts(33) = 7.05, ps < .001. Thus, children's behavioral detection of ambiguity is influenced by their own knowledge of the intended meaning of the message.

In summary, these analyses indicate that the pattern of children's pointing behaviors show evidence of ambiguity detection—children pointed more often to the referential alternative following an ambiguous message. However, they were not able to completely override the bias that their privileged knowledge creates as they pointed to the referential alternative at lower than chance levels when aware of the sticker's location, even when the message was ambiguous. In contrast, when unaware of the sticker location, they pointed to the referential alternative at chance levels following ambiguous messages.

Phase 2: Message Evaluation

Recall that in the second phase of the task, children were asked to directly evaluate the quality of the message (i.e., ''good'' or ''tricky''). If children understood the meaning of message ambiguity, they would indicate that ambiguous messages were ''tricky'' and clear message were ''good.'' Children's responses to the message evaluation question are displayed in Figure 1. Only children who successfully indicated that they knew what ''tricky'' meant at two consecutive time points (at least) were included in message evaluation analyses (n = 24 or 71% of the sample). The use of this criterion led us to include children who demonstrated consistent understanding of the term tricky across two consecutive time points. Thus, it allowed us to be confident that children's evaluations of messages as tricky or good in the message evaluation task were guided by their stable understanding of the meaning of ''tricky.'' Children who knew what ''tricky'' meant did not differ from the children who did not know what tricky meant in terms of age, verbal skills, or inhibitory control (ps > .05). The ANOVA revealed a main effect of message quality, $F(1, 22) = 21.92$, $\eta_p^2 = .50$, $p < .001$, and a significant interaction between message quality and age at testing, $F(2, 44) = 6.99$, $\eta_p^2 = .24$, $p < .01$. All other main effects and interactions were not significant. Note that this pattern of results was identical when using an even more stringent criterion, namely, children who answered the ''tricky'' question correctly at all assessment points.

Given that the role of knowledge in children's ability to explicitly detect ambiguity was of key theoretical interest in this experiment, comparisons at each age at testing were conducted separately for the knowledgeable and unknowledgeable conditions, rather than collapsing across knowledge type. Bonferroni corrections were used to account for the multiple comparisons. When unaware of the sticker location, preschoolers showed no differences in their evaluations of ambiguous (M = 47%, SD = 40%) and unambiguous messages as ''tricky'' (M = 35%, SD = 40%) when assessed at 4 years of age ($p > .05$). However, when tested at 4½ and 5 years, preschoolers were more likely to say that an ambiguous clue was ''tricky'' (M = 61%, SD = 44% at 4½ years; M = 78%, SD = 31% at 5 years) compared to an unambiguous clue (M = 33%, SD = 36% at 4½ years; M = 26%, SD = 39% at 5 years), $t(23) = 2.46$, $d = .70$, $p < .05$, and $t(23) = 5.01$, $d = 1.49$, $p < .05$, respectively. Similarly, when children were aware of the sticker location, they evaluated ambiguous and unambiguous messages similarly when tested at 4 years of age (p = . 27). At 4½ and 5 years of age, children, even when knowledgeable, were significantly more likely to say that an ambiguous message (M = 60%, SD = 41% at 4½ years; M = 67%

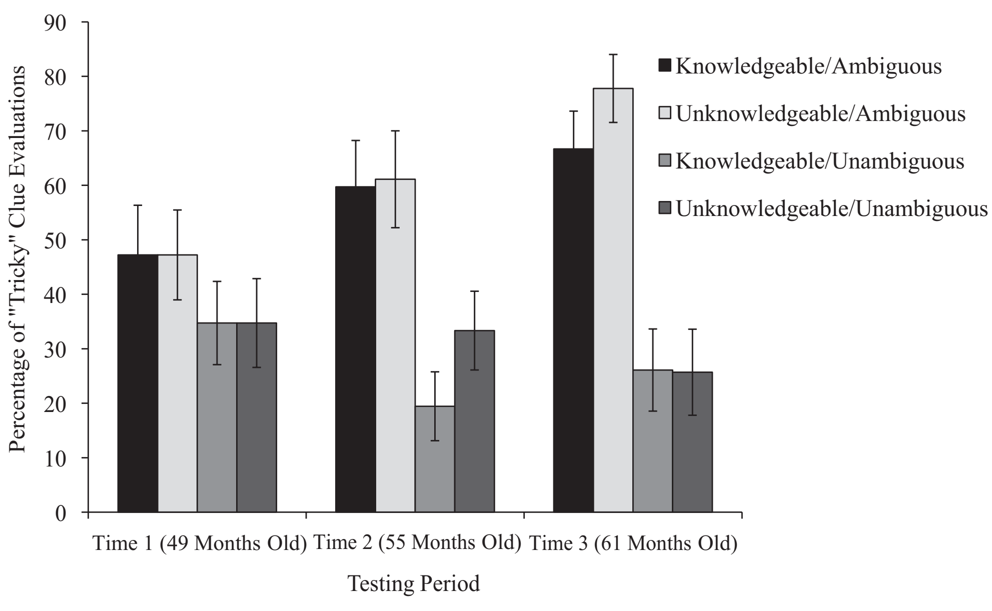

Figure 1. Percentage of times clues were evaluated as being ''tricky'' as a function of age and condition.

SD = 33% at 5 years) was tricky relative to an unambiguous message ($M = 19\%$, $SD = 31\%$ at 4½ years; $M = 26\%$, $SD = 36\%$ at 5 year), $t(23) = 3.73$, $d = 1.10$, and $t(22) = 3.60$, $d = 1.17$, respectively, both *p*s < .05.

We next compared preschoolers' responses on the message evaluation task to chance-level responding (50%) using one-sample *t* tests. At age 4, children did not respond to the message evaluation question differently from chance following ambiguous messages (*p*s > .74); however, there was an emergence of appreciation of message clarity in that there was a trend for unambiguous messages to be classified as ''good'' greater than chance, in particularly when children were knowledgeable, $t(23) = 2.00$, $p = .057$. This understanding became more established at 4½ years, when children's evaluations differed from chance in the two unambiguous message conditions (but not the ambiguous message conditions). Here, children correctly indicated that unambiguous messages were ''good'' more frequently than would be expected by chance in both the knowledgeable condition, $t(23) = 4.83$, $p < .001$, and unknowledgeable condition, $t(23) = 2.30$, $p < .05$. Similarly, when 5 years of age, regardless of their knowledge state, they were more likely than chance to say the message was ''good'' after hearing an unambiguous message, *t*s(23) = 3.43 and 3.08 for knowledgeable and unknowledgeable conditions, respectively, *p*s < .05. Importantly, when 5 years old, preschoolers evaluated an ambiguous message as ''tricky'' more than would be expected by chance, in the knowledgeable condition, $t(23) = 2.39$, $p < .05$, and unknowledgeable condition, $t(23) = 4.45$, $p < .001$.

Together, the results from analyses on children's message evaluations demonstrate a developmental progression in the detection of ambiguity. When 4 years of age, preschoolers do not explicitly judge a message to be ambiguous when either knowledgeable or unknowledgeable about the intended meaning of a message. When they are 4½ years of age, preschoolers evaluate ambiguous messages as tricky more often than unambiguous messages regardless of knowledge state. This pattern remains when children's responses are evaluated at 5 years of age. This suggests that children evaluate ambiguous and unambiguous messages differently from the listener's perspective even when provided with privileged contextual knowledge that would disambiguate the clues. Chance-level comparisons reveal a progression whereby children are able to identify message *clarity* at an earlier age than detecting message *ambiguity*.

What Is the Relation Between Implicit and Explicit Measures?

We assessed whether children's performance on implicit measures (eye movements) related to their explicit performance during the task (pointing, message evaluation). To explore these relations, we correlated the implicit and explicit measures of the message evaluation task within the three periods at which we assessed children's performance.

First, we assessed the correlation between children's duration of looking time toward the referential alternative and their pointing behavior. The condition of greatest theoretical interest in examining this relation was the knowledgeable–ambiguous condition as it is here that children are faced with a conflict between knowing the intended meaning and hearing an ambiguous message. In this condition, children who looked longer to the referential alternative were more likely to indicate by pointing that the listener might think the sticker was under the referential alternative. This relation was consistent across all three assessment points: 4 years, $r(32) = .51$, $p < .005$; 4½ years, $r(32) = .43$, $p < .05$; and 5 years, $r(32) = .39$, $p < .05$. Thus, children who looked at the referential alternative after hearing an ambiguous clue were more likely to indicate that the listener might think the sticker is hidden under that object, indicating that there is continuity between children's implicit and explicit behaviors. We also examined the relations in the unknowledgeable–ambiguous condition to assess relations when children did not have prior knowledge that may affect their sensitivity to ambiguity. In this condition, the only significant relation between pointing and eye gaze occurred when children were 5 years old, $r(32) = .51$, $p < .05$.

Next, to assess whether the visual consideration of the referential alternative was related to the child's explicit message evaluations, we correlated the duration of time spent looking at the referential alternative with the degree to which they said an ambiguous clue was ''tricky'' when knowledgeable about the location of the sticker. Children's duration of gaze to the referential alternative and their evaluations of the messages were not correlated concurrently at any age (all *p*s > .05) or across ages (*p*s > .05). Similarly, when unknowledgeable, children's fixation duration toward the referential alternative did not relate to their message evaluations (*p*s > .05). This indicates that children's implicit awareness did not predict the accuracy of their explicit message judgments.

The relations between children's pointing behavior and their explicit message evaluations were also evaluated with no significant relations emerging at any age when children were knowledgeable (all *p*s > .05). When unknowledgeable, 4-year-old children who pointed at the referential alternative following an ambiguous message were more likely to say that the clue was tricky, $r(24) = .48$, $p > .05$, but this relation was not significant at other ages (*p*s > .05).

Is Inhibitory Control Related to the Ability to Successfully Evaluate Clues From a Third-Person Perspective?

If inhibition is related to children's ability to suppress their knowledge in order to take into account the perspective of another (e.g., as per Nilsen & Graham, 2009), we would expect that children's inhibition skills would be related to their ability to detect ambiguity when they are knowledgeable. In order to assess this prediction, correlations between children's performance on the two inhibition tasks and their implicit and explicit measures of ambiguity sensitivity were conducted.

Preliminary analyses examined children's verbal and inhibition skills. Children's vocabulary skills, as assessed by the PPVT–III, improved significantly between 4 and 4½ years and between 4½ and 5 years, *p*s < .005 (see Table 2). Their vocabulary skills were not significantly related to their message evaluations at any age, *p*s > .08. Children's performance on the two inhibitory control tasks were significantly correlated at 4 years of age, $r(32) = .32$, $p < .05$, and at 4½ years, $r(32) = .59$, $p < .001$, and marginally significantly correlated at 5 years, $r(32) = .28$, $p = .053$. As such, composites were created by calculating the mean of the two inhibition tasks at each age. Children's composite inhibition skill at each age was significant correlated with inhibition at other ages (all *p*s < .05), indicating developmental consistency in inhibition skills. Moreover, children's skills improved significantly between 4 years of age ($M = 11.75$, $SD = 3.85$) and 5 years of age ($M = 13.81$, $SD = 2.42$), $t(33) = 3.53$, $p < .001$, and between 4½ years ($M = 11.78$, $SD = 3.95$) and 5 years, $t(33) = 3.18$, $p < .005$, but not between 4 and 4½ years of age, $p = .95$.

Table 2
Means (Standard Deviations) of Verbal and Inhibitory Control Measures at Different Testing Periods

Measure	Testing period		
	4 years old	4½ years old	5 years old
Day–night (out of 16)	10.68 (5.12)	10.79 (4.84)	13.21 (3.09)
Grass–snow (out of 16)	12.82 (4.34)	12.76 (3.99)	14.41 (2.96)
Inhibitory control total (out of 32)	23.50 (7.70)	23.56 (7.89)	27.62 (4.84)
PPVT–III raw scores	71.82 (14.81)	82.06 (13.56)	88.68 (13.95)

The inhibition composite score was used to examine the relations between inhibition and children's performance in the condition where they would be required to suppress their own knowledge to answer correctly (i.e., the knowledgeable–ambiguous condition). First, we examined the relation between children's gaze duration to the referential alternative, pointing to the referential alternative, and their inhibition skills. These analyses indicated that children's inhibition skills were not related to their gaze duration or their pointing behavior at any assessment point, *p*s > .05. Second, we examined the relation between inhibition and message evaluation (Table 3). Comparisons between inhibitory control skills and message evaluations were not correlated within the same assessment period at any age, *p*s > .05. Children's inhibition at 4 years of age was significantly correlated with the number of times they said a clue was ''tricky'' 6 months later, $r(23) = .56$, $p < .01$. As previous work has revealed significant relations between inhibitory control and language skills (e.g., Bernstein, Atance, Meltzoff, & Loftus, 2007; Carlson, Mandell, & Williams, 2004), partial correlations controlling for vocabulary skills were conducted in order to assess the unique relation between inhibition and ambiguity. The relation between children's inhibitory control at 4 years of age and message evaluation remained when verbal skills were controlled, $r(20) = .47$, $p < .05$. Furthermore, there was a significant correlation between early inhibitory control at 4 years and children's responses of ''tricky'' on the message evaluation task in the knowledgeable–ambiguous condition 1 year later at 5 years of age, $r(20) = .43$, $p < .05$. Thus, inhibition skills relate to the degree of success children have in the message evaluation task as they develop. More specifically, children who have better inhibitory control at a younger age demonstrate greater success later at suppressing their knowledge in order to appreciate that an ambiguous message would be unclear to a naive listener.

In order to assess whether inhibitory control was related *specifically* to the requirement of knowledge suppression (i.e., the knowledgeable–ambiguous condition), we assessed the relation between inhibition skills and the children's performance on the

Table 3

Bivariate (and Partial Correlations Controlling for Verbal Skills) Between Inhibitory Control and Percentage of Times Ambiguous Clues Were Labeled as "Tricky" at Different Testing Periods, in Different Knowledge Conditions

	Message evaluation condition					
	Knowledgeable–ambiguous			Unknowledgeable–ambiguous		
	4 years	4½ years	5 years	4 years	4½ years	5 years
Inhibitory control (4 years)	.08 (.17)	.56* (.49*)	.29 (.43*)	.27 (.24)	.06 (.02)	.38 (.33)
Inhibitory control (4½ years)	−.06 (−.06)	.27 (.32)	−.08 (−.09)	−.06 (−.07)	.01 (.02)	−.05 (−.01)
Inhibitory control (5 years)	.04 (.01)	−.24 (−.21)	−.20 (−.20)	.06 (.05)	.16 (.15)	.15 (.13)

*$p < .05$.

message evaluation task in the other three conditions (i.e., knowledgeable–unambiguous, unknowledgeable–ambiguous, unknowledgeable–unambiguous). At no time did the children's inhibitory control skills significantly correlate with their performance in any of the other conditions (all *p*s > .05). This pattern of results suggests that inhibitory control is related specifically to the act of suppressing one's knowledge to appreciate ambiguity from another person's perspective.

Discussion

Using a longitudinal study, we examined the developmental course of preschoolers' detection of referential ambiguity between 4 and 5 years of age. Across three assessment periods, we presented preschoolers with a message evaluation task that required them to judge the clarity or ambiguity of linguistic messages for another person. We also investigated whether inhibitory control skills were related to children's ability to detect ambiguity from a naive listener's perspective. Our results revealed a number of key insights into the emergence of preschoolers' appreciation of referential ambiguity.

First, children showed implicit sensitivity to ambiguity from a listener's perspective at 4 years of age, even when they possessed privileged knowledge that would disambiguate the statement from their own perspective. Specifically, children's eye gaze reflected sensitivity to the fact that an ambiguous message could refer to either object on the display. This finding is consistent with previous work documenting that children's eye gaze reveals early sensitivities to communicative ambiguity (e.g., Nilsen et al., 2008; Sekerina, Stromswold, & Hestvik, 2004). Second, children's pointing behaviors also reflected their detection of ambiguity by 4 years of age. That is, children were more likely to point to the referential alternative after hearing an ambiguous versus unambiguous message even when they were knowledgeable about the intended meaning of the message.

Third, children's explicit understanding of communicative ambiguity emerged between 4 and 5 years of age. At 4 years old, children's evaluations of messages did not reflect a clear understanding of message quality. There was, however, a trend for children's message evaluations to reflect an understanding of message *clarity* that more clearly emerged at 4½ years of age. That is, at 4½ years, regardless of their knowledge state, children indicated that an unambiguous message was sufficient to guide a naïve listener's actions. Six months later, when 5 years of age, children's ability to detect *ambiguity* emerged. That is, they indicated that ambiguous messages would not be sufficient for a naïve listener to identify an intended referent. These results suggest that children are first able to understand that clear or unambiguous messages lead to listener understanding and later understand that poor messages lead to listener miscomprehension. Furthermore, our results demonstrate that children, by 5 years of age, understand that a message can be unclear from a naïve listener's perspective even though they know the intended location.

Children's detection of ambiguity at 4 years of age, as indexed by pointing behavior, did contrasts with their performance on a second explicit measure of ambiguity understanding, namely, message evaluations. Here children's appreciation of ambiguity was not apparent until they were 4½ years old. What might account for this discrepancy? We propose that children's pointing behavior reflects sensitivity to ambiguity prior to explicit message evaluations because successful pointing does not require children to fully *understand* message ambiguity. That is, in order to successfully evaluate a message as ambiguous, children must understand that there is something inadequate about the message for the naïve other. In contrast, when pointing, children do not need to have this understanding; they only have to appreciate that the message could refer to either referent. When generating their points, it may be the case then that children seek to find a ''match'' between the description and the potential referents. When presented with an ambiguous clue, they could look toward the referential alternative, decide that it ''fits'' and point to that location, without fully appreciating that this message does not provide clear direction for the listener.

Even though children differentiate between ambiguous and unambiguous messages, the measures of children's gaze patterns demonstrated that they did, at some level, conflate their own knowledge with that of the listener (albeit not completely). It is not surprising that children's knowledge biases their performance given that adults are not able to suppress their own privileged knowledge when interpreting statements from a naive listener's perspective (Epley, Keysar, Van Boven, & Gilovich, 2004; Hanna, Tanenhaus, & Trueswell, 2003; Keysar, Barr, & Horton, 1998). Interestingly, children's explicit evaluations of messages, at later ages, did not show evidence of conflation. Specifically, when children indicated that they understood communicative ambiguity, they were just as successful when knowledgeable as when unknowledgeable. Thus, although implicit measure showed early sensitivities to communicative ambiguity, they also showed lingering biases even at times when children's explicit message evaluations showed more success. Accordingly, these different levels of measurement in this study allowed for a more nuanced understanding of the children's processing of communicative ambiguity.

Fourth, we found both congruity and incongruity across children's implicit and explicit responses. In the first phase of the message evaluation task, children who looked proportionally longer at the referential alternative were more likely to indicate, via pointing, that the listener might think the sticker was hidden in that location. However, as indicated previously, the pointing measure does not necessarily indicate that children understand message ambiguity, but rather that ambiguity was detected. In contrast, our measure of children's understanding, namely, their explicit judgments of message clarity, did not show any relation to the children's implicit performance. That is, children who spent more time considering alternative options were not more likely to say that an ambiguous message was tricky. This latter dissociation between children's implicit and explicit responses has been found in previous studies (e.g., Nilsen et al., 2008; Sekerina et al., 2004). For example, Sekerina et al. (2004) found that although children's eye gaze showed detection of ambiguity after hearing ambiguous pronouns, their explicit responses did not reflect sensitivity to the ambiguity (whereas adults did). Thus, it appears that children can unconsciously access multiple referential representations without demonstrating this recognition through explicit means. The dissociation evidenced by children may be more reflective of a general unawareness children have for the knowledge that is conveyed through their eye gaze (Ruffman et al., 2001; Sekerina et al., 2004).

Similarly, early implicit awareness of communicative ambiguity did not predict later explicit success. That is, although children demonstrated earlier implicit sensitivity to communicative ambiguity, this did not directly relate to later development of explicit understanding. The lack of a relation may reflect the fact that other skills make a greater contribution to children's development of explicit ambiguity detection. For example, the discrepancy that children evidence between their implicit and explicit processing may be attributed to children's underdeveloped executive function skills (Robin & Holyoak, 1995). Specifically, in the present study, if it is the case that children's explicit message evaluations are influenced by their own knowledge of the intended meaning of a statement, one would expect that cognitive skills that allow for the suppression of such knowledge would assist in their detection of ambiguity.

Finally, our results indicate that children with better inhibitory control at the first time of testing were more successful at understanding message ambiguity 6 and 12 months later. This relation was specific to the condition where children had privileged knowledge of the intended meaning of an ambiguous message. Thus, it appears that inhibition aids children in the specific act of suppressing their own knowledge state during message evaluation rather than predicting a general ability to evaluate messages.

Our findings add to a growing body of literature highlighting the role that inhibition plays in children's interpersonal and communicative success. For example, Nilsen and Graham (2009) demonstrated that children's inhibitory control skills were related to their ability to take the perspective of a conversational partner during a referential communication task. The mechanism by which inhibitory control plays a role in the current study may be through allowing children to suppress their knowledge of the intended meaning of the message to appreciate that the semantic content contained in ambiguous messages was insufficient from an ignorant listener's perspective. Of more general relevance, inhibitory control may allow children to overcome (albeit partially) a ''curse of knowledge'' wherein their judgments about a more naive individual's perspective would be biased (Birch, 2005). The inhibitory control measures in the present study were ''conflict'' tasks in that children were required to both suppress a response and hold in mind and produce an alternative response (i.e., as opposed to ''delay'' tasks that require withholding a response). Tasks such as these are thought to pose working memory demands (e.g., Carlson & Moses, 2001). As such, it may be that the combination of suppression (i.e., of own knowledge) and working memory (i.e., holding the clue in mind in order to evaluate it) allows children to detect ambiguity when they have privileged knowledge.

Research has not always demonstrated a link between inhibitory control and children's ability to ignore privileged information. For example, Bernstein et al. (2007) found that preschoolers' performance on tasks of hindsight bias did not correlate with their performance on tasks of inhibition. These findings are consistent with our results, in that children's inhibitory control was not related to their ability to detect ambiguity when knowledgeable within the same assessment period. It was only when the correlations were examined across a developmental progression that significant relations emerged between inhibitory control and understanding ambiguity. Thus, our findings highlighting the trajectory of skill interrelations are similar to those of other longitudinal and microgenetic studies, which have demonstrated that children's inhibitory control predicts later improvements on false-belief tasks (Carlson et al., 2004; Flynn, 2007; Flynn, O'Malley, & Wood, 2004; Hughes, 1998; Hughes & Ensor, 2007), and are consistent with executive emergence accounts of theory of mind development, which posits that a certain degree of executive ability is required before the construction of mental concepts (Moses, 2001). Our results particularly indicate that better inhibition sets children up for the development of the ability to detect ambiguity from a naïve listener's perspective at an earlier stage than children with less developed inhibition skills. As such, we posit, albeit speculatively, that children who demonstrate early inhibitory success will have enriched social experiences that allow for the development of perspective-taking skills. Thus, through these interactions, they will develop a greater ability to appreciate communicative ambiguity from a naive listener's perspective (see Hughes & Leekam, 2004, for a similar argument regarding the role that executive functioning plays in mentalizing skill development).

In closing, the present study is the first to use a longitudinal design to examine the trajectory of preschoolers' ability to implicitly and later explicitly detect ambiguity in messages, thereby adding to the growing literature demonstrating how children's cognitive skills first emerge on implicit levels that later are demonstrated in more explicit ways (e.g., Ahmed & Ruffman, 1998; Garnham & Ruffman, 2001; Siegler, 2000). Furthermore, the present work demonstrates that children's inhibition skills assist them in subsequently overriding their own privileged knowledge when explicitly evaluating messages from a third-person perspective.

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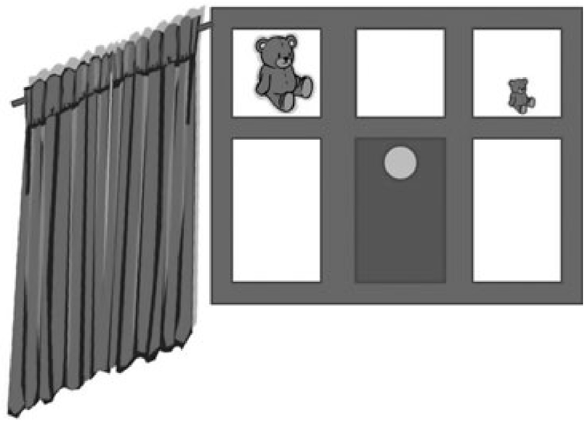
Appendix A

Schematic depiction of shelf apparatus used to present objects. Curtain on left was rotated to manipulate children's knowledge of the sticker location. The center circle represents the video camera that recorded children's eye movements.



Appendix B

Table B1
Object Sets and Associated Ambiguous and Unambiguous Adjectives

Object sets	Ambiguous adjective	Unambiguous adjectives
Shoes (different sizes, same color)	Blue	Small, Big
Books (same size, different colors)	Small	Pink, Blue
Horses (same size, different colors)	Big	Brown, Black
Flowers (different sizes, same color)	Red	Big, Small
Bears (different sizes, same color)	Black	Small, Big
Cars (same size, different colors)	Small	Red, Silver
Bowls (same size, different colors)	Big	Green, Yellow
Elephants (different sizes, same color)	Gray	Big, Small
Ducks (different sizes, same color)	Yellow	Small, Big
Cups (same size, different colors)	Small	Red, Blue
Frogs (same size, different colors)	Big	Pink, Green
Stars (different sizes, same color)	Yellow	Big, Small

Table B2
Overview of Conditions

	Knowledgeable child	Unknowledgeable child
Ambiguous instructions for listener	Curtain OPEN to child during hiding of sticker Objects: Large and small black bears e.g., ''It's under the *black* bear''	Curtain CLOSED to child during hiding of sticker Objects: Large and small black bears e.g., ''It's under the *black* bear''
Unambiguous instructions for listener	Curtain OPEN to child during hiding of sticker Objects: Red and silvers cars e.g., ''It's under the *red* car''	Curtain CLOSED to child during hiding of sticker Objects: Red and silvers cars e.g., ''It's under the *red* car''