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Preschoolers' Sensitivity to Speaker Action Constraints to Infer Communicative Intent

by

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Abstract

In three experiments, I investigated children's use of speaker action constraints to infer communicative intent and resolve ambiguity. In Experiment 1, 22 3-year-olds were presented with arrays of 8 objects and were asked to retrieve objects from the display. Trials varied in terms of whether the speaker's hands were empty or full when she requested an object, and whether the request was ambiguous (more than one referent) or unambiguous (one referent). Experiment 1 demonstrated that children were sensitive to referential ambiguity but not to speaker action constraints. In Experiments 2 and 3, a training phase and eye gaze measures were added to test 19 4-year-old and 20 3-year-old children, respectively. Children in both groups were sensitive to speaker action constraints, but only 4-year-olds used this information to make explicit referential decisions. These findings demonstrate the developmental emergence of the use of speaker action constraints as a cue to communicative intent.

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Preschoolers' Sensitivity to Speaker Action Constraints to Infer Communicative Intent

Understanding the intentions of our social partners is a critical component of successful communication. Language is often ambiguous, and without the ability to infer the goals and intentions of others, communication would be an onerous process requiring constant clarification of our messages. Consider, for instance, a situation in which a parent who is walking with a child in a parking lot full of cars, exclaims "Oh, a car!". In this situation, the intended meaning of the phrase is formally ambiguous, as there is not enough linguistic information presented to identify which car is the referent of the parent's exclamation. However, if one car is speeding through the parking lot, ambiguity is reduced as a result of the child's ability to gauge the parent's situation-specific intention (i.e., to avoid being in danger). Understanding a communicative partner's intention can be considered a component of pragmatic competence, or an understanding of *how* language is used to communicate with others. That is, a pragmatically competent listener would identify the speeding car as the intended referent, even if no additional linguistic information was provided. The present study was designed to investigate preschool children's ability to infer a speaker's intent based on his/her action constraints, and use that information to resolve referential ambiguity.

The Emergence of an Appreciation for Intentionality

A growing body of research suggests that from as early as the first year of life, infants begin to perceive humans as intentional agents (e.g., Bretherton, 1991; Gergely, Nadasdy, Csibra & Biro, 1995; Woodward, 1998). In one such study, Woodward (1998) used a habituation paradigm to investigate whether 5- to 9-month-old infants would selectively attend to aspects of a person's actions that were relevant to his/her underlying intention. Infants were habituated to videos of an experimenter reaching for and grasping one of two toys. Once infants had been habituated, the position of the toys was reversed and infants were shown a video that manipulated either the goal of the reach (i.e., physical movements were the same, but the experimenter grasped a different toy) or the experimenter's physical movements (i.e., the experimenter grasped the same toy as she had during the habituation phase, but her physical movements were in a different direction). The researchers found that 9-month-old infants demonstrated a stronger novelty response (i.e., longer looking time) when shown the goal-manipulated video, suggesting that they were attending to the experimenter's actions as they related to her end goal and not simply to her physical movements. Five-month-old infants showed a similar pattern of responding, although the effect was not as robust. Thus, prior to their first birthdays, infants can detect the intention underlying an individual's behaviours.

Further evidence for the emergence of an appreciation for intentionality during infancy comes from studies demonstrating that young infants will take the most rational approach to reaching a speaker's goals, even if the speaker has never demonstrated that approach. For example, Meltzoff (1988) demonstrated that 14-month-old infants would imitate an experimenter's unusual method of turning on a light (by touching it with her forehead). A follow-up study (Gergely, Bekkering & Kiraly, 2002) used a similar procedure, but examined whether the propensity to imitate the unique action could be impacted by cues about the experimenter's intent. That is, Gergely et al. (2002) replicated Meltzoff's procedure but manipulated whether the experimenter's hands were full or empty when she performed the head action. A significantly smaller number of 14-month-old infants replicated the head action when the experimenter's hands were occupied compared to when her hands were empty, choosing more often to use their own hands to turn on the light. Thus, infants did not simply emulate the experimenter's actions with the object, but used the most rational approach to achieve what they perceived to be the individual's end goal (turning on the light). If the experimenter's hands were occupied when she demonstrated the head action, infants seemed to make the assumption that the experimenter *would* have used her own hands had she been capable of doing so. However, if the experimenter's hands were empty while demonstrating the head action, infants had reason to assume that using one's head offered some advantage for the task. Gergely et al. (2002) referred to this phenomenon as "rational imitation". A later study by Schwier, van Maanen, Carpenter and Tomasello (2006) conducted a different but analogous task with 12-month-olds, and found that even at this younger age infants showed an appreciation for the intentionality of rational action.

As indicated by the above studies, the ability to detect the intentionality of human *actions* and *behaviours* emerges early in infancy. At some point during development, however, children extend this basic understanding of intentionality and begin to appreciate less directly observable intentions – communicative intentions. Intentions are defined as "private mental states" (Malle, Moses & Baldwin, 2001), however, the primary goal in communication is to allow listeners *access* to these private intentions, thus enabling one's communicative partner to accurately infer what we mean. According to Bara (2010), communicative intentions form a distinct subtype of intentionality. Specifically, unlike intentional actions or behaviours, communicative intentions require "the intention to communicate something, plus the intention that the intention to communicate that particular something be recognized as such" (p. 82).

The ability to infer a speaker's communicative intention becomes particularly important when one is faced with ambiguous language. In fact, listeners are faced with ambiguous language quite regularly, despite the fact that we do not often recognize its presence (Spivey, Tanenhaus, Eberhard, & Sedivy, 2002). Two primary forms of ambiguity, lexical and structural, have been researched with particular focus on the types of information that individuals consider as they resolve ambiguity in real time (Trueswell & Gleitman, 2004). *Lexical ambiguity* refers to words that have more than one meaning (e.g., bat, stand, etc.). The second type of ambiguity, *structural ambiguity*, occurs when the structure of a sentence allows for more than one interpretation. For example, the statement "The chicken is ready to eat" may refer to a situation in which a chicken is about to be served for dinner, or a situation in which the chicken is the agent ready to consume its food. In addition to lexical and structural ambiguity, we can also consider a more global type of ambiguity, such as when a speaker fails to provide enough linguistic information to determine the correct referent in a particular communicative context. For example, consider the ambiguity that is present when someone asks, "Can you hand me the book?" in a library full of books. Thus, as language is produced and comprehended, listeners are faced with the ongoing need to draw on extralinguistic sources of information, or information beyond what is included explicitly in the speech stream, to resolve ambiguity.

Inferring a Speaker's Communicative Intent in Adulthood

Research has established that adults use a broad range of extralinguistic cues for constraining the referential domain (i.e., the number of possible referents for a given phrase), which in turn narrows the potentially infinite number of referents and aids in ambiguity resolution. Again, consider a scenario in which two individuals are sitting in a library and one says to the other, "Can you hand me the book?" In this case, the referential domain is incredibly large (i.e., all books in the library), the phrase is ambiguous (i.e., there is not enough linguistic information to determine which book the speaker is referring to), and the listener must limit the referential domain to determine the intended referent. To complete this communicative task, adults use many sources of information such as a speaker's eye gaze (e.g., Hanna & Brennan, 2007), paralinguistic cues (e.g., Snedeker & Trueswell, 2003), and gestures (e.g., Goldin-Meadow & Wagner, 2005).

In addition, adults can use information from the broader communicative context to resolve ambiguity in communication. For example, research has demonstrated that adults can attend to a speaker's action constraints (i.e., what a speaker is able or unable to do in a given task) when interpreting utterances and inferring speaker intent. Hanna and Tanenhaus (2004) investigated whether adult listeners use information about a speaker's goals and pragmatic constraints to identify the referent of an ambiguous definite noun phrase. Participants' eye movements were tracked as they assisted a confederate ("cook") in following a recipe. The materials for the recipe were spread across two spatial areas, some in the participant's area and others in the cook's area, although the materials in the cook's area were also accessible to the participant. Each participant heard a series of instructions, one of which was a critical instruction that was formally ambiguous (e.g., "Could you put *the cake mix* next to the mixing bowl?" in the presence of two boxes of cake mix). During the critical instruction, one of the potential referents was located in the participant's area, and the other in the cook's area. The timing of the critical instruction was manipulated so that it either occurred when the cook's hands were empty or full. Thus, the ability of the cook to reach various objects provided a potential domain restriction for the listener. Specifically, when the cook's hands were empty, participants should have demonstrated a preference for considering the cake mix in their *own* area, because that would have been the most plausible referent given the cook's reaching ability (i.e., the cook could have reached for the cake mix in her own area without the help of the participant). Conversely, when the cook's hands were full, participants should have also considered the cake mix in the cook's area as a potential referent, as the cook was no longer capable of reaching that referent herself.

The results of Hanna and Tannenhaus' (2004) study suggested that participants' referential domain of interpretation was quickly modified by consideration of the cook's goals and pragmatic constraints. Thus, in the structured setting of the experiment, adults were efficient at inferring a speaker's communicative intent and resolving referential ambiguity. However, adults in this study participated in two practice trials to demonstrate the cook's action constraints and also received explicit direction at the outset of the task that their role would be to "help [the experimenter] out either by moving the objects that [the experimenter] couldn't reach or by moving one of [the experimenter's] own objects if she couldn't do it herself" (p. 109). Therefore, although the findings are theoretically interesting, it is unclear whether adults would spontaneously use information about speaker action constraints to resolve referential ambiguity.

Inferring a Speaker's Communicative Intent in Childhood

The question of young children's sensitivity to the communicative intentions of others has received a great deal of attention in the word learning literature. Research on word learning has demonstrated that sensitivity to a speaker's intentions can assist children in determining the intended referent of a novel word. For example, studies have demonstrated that young children's tendency to link a novel label with an object can be directed by a speaker's gaze direction (e.g., Baldwin, 1993; Moore, Angelopoulos, & Bennett, 1999), a speaker's affective and/or behavioural cues (e.g., Tomasello, Strosberg & Akhtar, 1996; Behne, Carpenter, & Tomasello, 2005), and the relative novelty of objects or actions in the discourse context (e.g., Akhtar, Carpenter, & Tomasello, 1996). However, the notion of speaker intent addressed in these studies pertains only to the use of *novel* labels, and how the meaning of a *new* word is acquired on the basis of socially provided cues. In contrast, only recently have researchers begun to examine how knowledge of speaker intent may guide children's understanding when faced with *familiar,* although formally ambiguous, language. For example, Berman, Chambers and Graham (2010) recently demonstrated that 4-year-olds can use a speakers' vocal affect to infer a speaker's referential intent.

It is still unclear, however, whether children can use information from the broader communicative context of an interaction to infer a speaker's intention when faced with familiar but ambiguous language. In the only study conducted on this issue to date, Grosse, Moll and Tomasello (2010) examined whether 21-month-old infants demonstrated an appreciation for the cooperative logic of requests. That is, they asked whether 21-month-olds interpret ambiguous messages using a collaborative communicative framework, assuming as adults do that people tend to make requests for things that they cannot easily carry out themselves. To address this question, an experimenter made a potentially ambiguous request when she asked infants to retrieve one of two identical objects. The only difference between the objects was their distance from the experimenter: one object was within her reach on a table she was seated at, and the other was out of her reach on a different table, almost 5 feet away. The experimenter made the request in one of three conditions: hands-free (one of her hands was empty), hands-occupied (she held an object in each hand), and a free-choice baseline condition (one of her hands was empty, but no request for help was made). Grosse and colleagues concluded that 21-month-olds did understand the cooperative logic of requests, as children chose the distant object significantly more often in the hands-free condition than they did in both the hands-occupied and baseline conditions.

However, several issues with Grosse et al.'s study make the findings difficult to interpret. That is, children's "successful" performance in the hands-free condition still corresponded to children selecting the distant object at chance level; a significant result due *only* to the bias against the distant object in the other two comparison conditions. However, the bias against the distant object is clarified by the presence of additional cues in the hands-occupied and free-choice conditions. First, the hands-occupied condition included an additional sentence ("I will come over to you") at the beginning of each trial in order to give the experimenter a reason to occupy her hands; she picked up some objects as though she intended to bring them to the child. However, informing children of her intention to get up and move from the table might have provided children in the hands-occupied condition with additional information; specifically, that her action constraints were flexible and if she wanted the distant object she could theoretically get up and move towards it. In the hands-free condition, the experimenter gave no indication that she could move from behind the table during the trials. The utterance in the free-choice baseline condition also provided information that might have resulted in a bias against the distant object, in that the experimenter did not use a definite noun phrase as she did in the hands-free and hands-occupied conditions (e.g., "Take *the* battery"). Instead, in the free-choice condition the experimenter told the infants to "Take *a* battery". Indefinite noun phrases imply that there is no particular referent in mind, whereas definite noun phrases like those used in the hands-free and hands-occupied conditions denote that a speaker has a particular referent in mind (Maratsos, 1974). Children begin to use determiners around 2-years of age, and are thought to develop the cognitive abilities necessary to understand determiners even prior to 2-years (Rosendaal & Baker, 2008). Thus, children in the free-choice condition may have shown a bias against the distant object because the experimenter implied that it did not matter which referent was chosen, and the distant object obviously required more effort to retrieve (i.e., they would have to go and retrieve it and then bring it over to the experimenter).

The present set of studies was designed to test the hypothesis that children attend to a speaker's action constraints to judge communicative intent and resolve ambiguous messages. Specifically, I investigated whether 3- and 4-year-old children consider the actions available to a speaker when judging the speaker's communicative intent. Across three studies, preschoolers were asked to help an experimenter pack a backpack with various toys from within a toy house display. Two factors were varied across trials: whether the experimenter's hands were empty or full at the time of the instructions to retrieve objects, and whether the instructions were ambiguous (i.e., two potential referents in the array – one located within the experimenter's reach and the child's reach, and one located within the child's reach only) or unambiguous (i.e., only one potential referent in the array). The ability of the experimenter to reach the toys in the house offered a potential referential domain restriction during the ambiguous instruction trials. That is, when the experimenter's hands were empty, I expected that children would restrict the referential domain to the toys within his/her own area, more often selecting the referent that only s/he could reach. The child's preference for toys in his/her own area should persist even when there is an equally plausible referent in the experimenter's area, as the experimenter would reach for that toy herself if it were the intended referent. Conversely, when the experimenter's hands were full, I anticipated that children would expand the referential domain to include the toys in the experimenter's area, as the experimenter was no longer capable of reaching those toys herself. The ambiguous sentences used in the present experiments were globally ambiguous, in that referential ambiguity was present even following the conclusion of the sentence. That is, the speaker did not provide enough linguistic information for children to make a correct referential decision, and children were required to draw on extralinguistic information to infer the experimenter's communicative intent.

Experiment 1

Participants

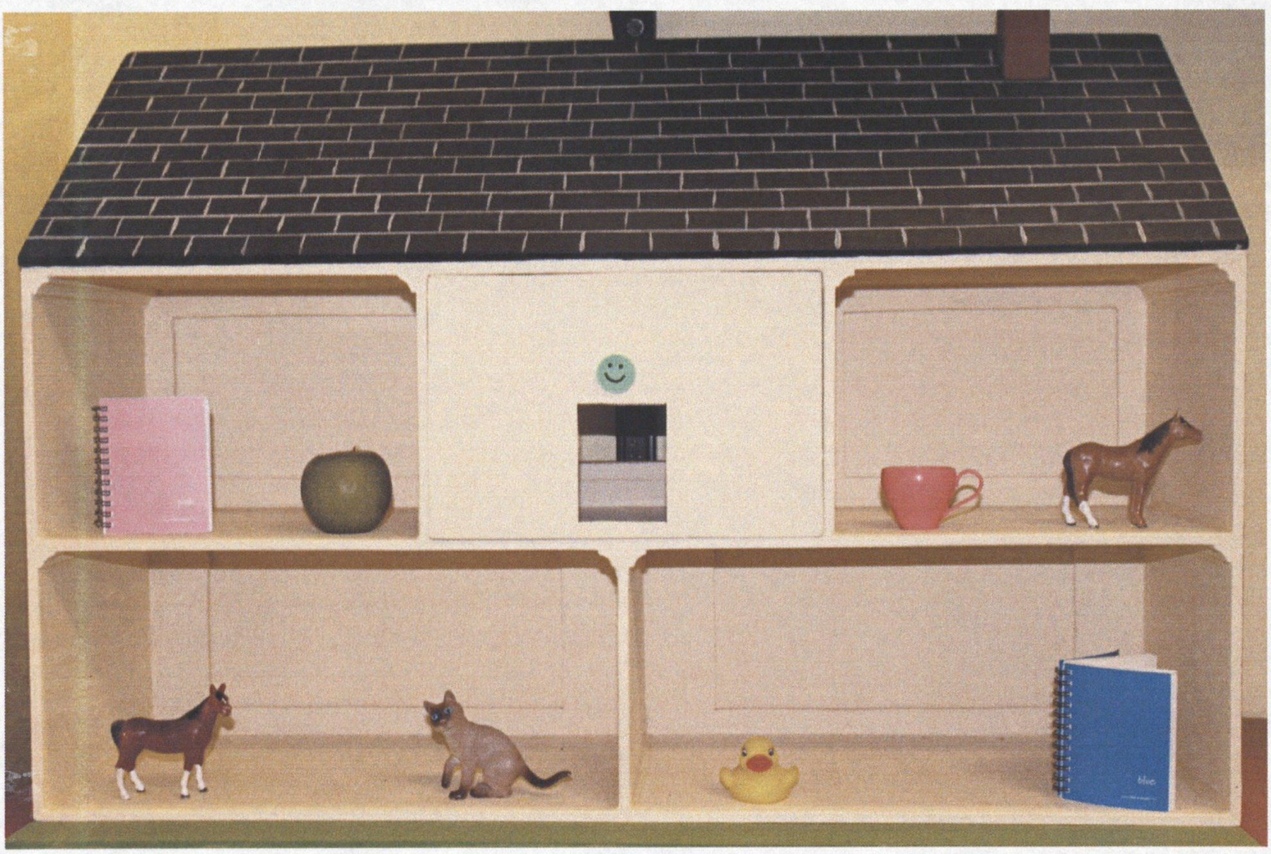
Data from 22 3-year-olds were included in the final sample (10 girls, 12 boys; $M = 36.21$ months, SD = 1.07) for Experiment 1. An additional 5 children were tested but excluded from analyses due to unwillingness to participate (n = 2), and experimenter error (n = 3). Prior to recruitment, ethics approval was obtained from the Conjoint Research Ethics Board at the University of Calgary (see Appendix A). Participants were then recruited through advertisements within the community (e.g., health clinics, newspapers). Children were from homes in which English was the primary spoken language, were from varied socioeconomic backgrounds, and were primarily Caucasian. Children were given a t-shirt and certificate for their participation. Parents received a follow-up letter describing the results of the study if they indicated that they were interested in receiving the results.

Materials

A large toy house (W 36" x H 16 ½") with five compartments was built specifically for this study (see Figure 1 below). The toy house consisted of three upper compartments (W 12" x H 8") and two lower compartments (W 18" x H 8"). Two latched doors on the back of the toy house allowed a second experimenter to place the objects inside of the house for each set of trials. A camcorder was placed behind the children to record object selections.

Figure 1.

Experiment set-up.



Twenty-four objects were used in Experiment 1: eight objects for a warm-up phase, eight objects in the first testing block, and eight objects in the second testing block. Twelve of the objects (four from the warm-up phase, four from the first testing block, and four from the second testing block) belonged to a pair but differed in color from one another. Objects were selected using the MacArthur-Bates Lexical Developmental Norms, with the criteria that at least 95% of 30-month-olds in a normative sample should be able to understand or produce the object names. There was only one exemplar of each of the other twelve objects. See Table 1 for a list of the stimuli that were used.

Procedure

Before the experiment began, parents and children were brought to the playroom. The first experimenter (E1) explained the details of the study to the parent, who then signed the consent form (Appendix B). E1 also took the time to get acquainted with the child and ensure that s/he was comfortable. Children were then brought into a quiet testing room and seated in a chair in front of the toy house. Parents observed the study from a room on the other side of a two-way mirror, and a baby monitor allowed parents to hear the procedure. The child was then introduced to the second experimenter (E2), at which time E1 began the training phase of the study.

To introduce the task to each child, E1 explained that they would be playing with a toy house, and that E2 would put different toys into the house for the child to look at. E1 told the child that a dog puppet named "Spot" was going to a friend's house and would like to bring some toys to show his friend. Then, E1 showed the child a red backpack and explained that E2 was going to put different toys in the house, which the child would help place in the backpack upon Spot's request. Children were reminded to wait for Spot's instructions before touching the toys.

Table 1.

Stimuli for Experiment 1.

Phase	Instruction Type	Referent 1	Referent 2
Warm-up	Warm-up	Red Car	Silver Car
	Warm-up	Yellow Fork	Green Fork
	Warm-up	Toothbrush	
	Warm-up	Airplane	
	Warm-up	Plastic Orange	
	Warm-up	Crayon	
Testing Set 1	Ambiguous	Light Brown Horse	Dark Brown Horse
	Ambiguous	Pink Book	Blue Book
	Unambiguous	Rubber Duck	
	Unambiguous	Plastic Cup	
	Reminder	Plastic Apple	
	Reminder	Cat	
Testing Set 2	Ambiguous	Brown Cow	Black Cow
	Ambiguous	Red Spoon	Yellow Spoon
	Unambiguous	Wooden Chair	
	Unambiguous	Dog	
	Reminder	Elephant	
	Reminder	Infant Shoe	

Warm-Up Phase. To begin the warm-up phase, E2 placed the first set of eight objects into the outer four compartments, with two toys in each compartment. Small stickers were located on the floor of each of compartment to ensure that the objects were placed in the same location across testing blocks and participants. As E2 placed the objects into the compartments, E1 named the objects with the child, one at a time, to ensure that children visually attended to each object in the array, and knew the object labels. When the second item of a pair was placed into a compartment, E1 emphasized that the object was part of a pair (e.g., "Oh, and *another* horse!").

After the objects were placed in the house by E2, E1 followed a dialogue (Appendix C) in which she explained that she could only reach toys from the side to which she was closest, and that only the child could reach the objects in the far side of the house. To get children comfortable picking up the toys and placing them in the backpack, E1 had the child point out the two sets of paired objects (e.g., "Can you point to the two cars in the house?"). Once the child had identified a pair of objects, E1 retrieved the exemplar closest to her, placed it in the backpack, and then explained to the child that she needed his/her help to retrieve the other one (e.g., "I can't reach the other one. Can you hand me the other car?"). This was done for the two sets of paired objects, after which point E1 emphasized that the child had a really good seat because s/he could reach *all* the toys in the house, and E2 removed the remaining objects.

Test phase. Immediately after completing the brief warm-up phase, E2 placed the first set of test objects into the compartments. E1 again drew the child's attention to each object by naming the objects, one-by-one, as they were placed in the house, and again emphasized that certain objects were part of a pair.

Six trials were conducted within each of the two testing blocks (see Table 2). Two of the trials within each block were *ambiguous instruction* trials, for which E1's request was ambiguous due to the presence of more than one potential referent inside the house. Two of the trials were *unambiguous instruction* trials, for which the child was simply asked to select a non-ambiguous referent and place it in the backpack. The unambiguous instruction trials were included to prevent children from developing specific expectations regarding which objects E1 would request, such as an expectation that the referring expressions would always be ambiguous or that the E1's utterance would always refer to a member of a pair. Lastly, two of the trials were *reminder instruction* trials, for which E1 verbally and visually showed the child what she could and could not reach in the house. For the two ambiguous, two unambiguous, and two reminder trials, E1's hands were empty for one trial and full (i.e., holding the backpack with both hands) for the other. The six trials within each testing block were presented in a quasi-randomized fashion, and the position of the objects within the toy house was counterbalanced, with the exception that the critical objects were always located in the outermost spaces. Placing the paired objects as far as possible from their match was done purposefully to ensure that E1's reaching constraints were highly salient for the ambiguous instruction trials.

At the beginning of every type of trial, E1 drew the child's attention to herself (e.g., "Look at me!") and showed the child that her hands were either full or empty. When E1's hands were empty, she held her palms face-up in front of the child and said, "My hands are *empty*!". When E1's hands were full, she held one side of the backpack with each hand, raised it in front of the child and said, "My hands are *full*!" E1 then directed the child to look back at the smiley face placed above the camera opening. When the child's eye gaze was directed at the smiley face, E1 told the child which object Spot would like (e.g., "Spot wants the *horse*!") and directed the child to put that object in the backpack (e.g., "Put the *horse* in the backpack!"), which was either in E1's hands (during the hands-full trials) or open on the floor beside the child's chair (during the hands-empty trials). During and after verbalizing each instruction, E1 directed her eye gaze toward the child to avoid providing any nonverbal cues as to the intended referent.

Table 2.

Instruction type and hand status combinations.

Instruction Type	Hands
Ambiguous	Empty vs. Full
Unambiguous	Empty vs. Full
Reminder	Empty vs. Full

During the reminder instruction trials, however, the procedure differed slightly. During the reminder hands-empty trials, E1 requested an object that was located in her own area, but rather than ask the child to place the object in the backpack, E1 said, "I'll get it!" and reached for it herself. During the reminder hands-full trials, E1 requested one of objects located within the participant's area, but rather than ask the child to retrieve the object, E1 directed her gaze at the object, with her hands holding the backpack, and said, "I can't get it!". If a child failed to respond to an instruction within about 10 seconds, or asked for clarification, E1 repeated the instruction.

Total testing time took approximately eight minutes including the warm-up and test phases. Following completion of the experiment, parents were debriefed about the expected results of the study. All children received a small toy, a t-shirt, and a "Child Scientist" certificate for their participation.

Coding

Two key dependent measures were coded. First, latency to object selection reflected the total time that elapsed between the onset of the noun (e.g., the /b/ sound in "book") and the sound of the object being dropped into the backpack, and was coded to establish whether or not children were sensitive to the ambiguity present in the ambiguous instruction trials and the speaker's hand action constraints. A research assistant who was unaware of the hypotheses of the study coded this from the scene camera video. Five randomly selected participants (23% of the sample) were coded by a second research assistant to provide a measure of inter-rater reliability of the latency to object selection data. Intraclass correlation coefficients (ICCs) were used to establish the level of agreement between coders, as this statistic assesses the pattern and level of agreement of raters (Sattler, 1992). The ICC coefficient indicated that there was a excellent level of agreement between raters, ICC (39) = .96, $p < .001$.

Second, children's final object selections were used as an indicator of their overt ability to attend to the speaker's action constraints and resolve ambiguity during *ambiguous instruction* trials. During the *ambiguous instruction* trials, final object selections were coded as the object that the child touched first - either in the experimenter's area or in the participant's area. The referent in the participant's area was always considered the *target* object, and the other toy from the pair in the experimenter's area was always considered the *referential alternative*. Only selections of the target and referential alternative were coded, as no children selected a distractor object. Children's object selections for the *unambiguous instruction* and *reminder instruction* trials were not analyzed, as there was only one potential referent for these trials, and all children selected the correct object. Final object selections were coded by E2 during the experiment, but were also re-coded by the primary coder to ensure inter-rater reliability. There was 100% level of agreement between raters on this variable, which resulted in a Cohen's kappa coefficient of 1.00.

Results

Latency to Object Selection. For this variable, I hypothesized that there would be a main effect of instruction type as well as an interaction between instruction type and hands. That is, if children *did* recognize the ambiguity, their response latencies should have been significantly shorter for unambiguous instruction trials (for which there was only one potential referent) than for the ambiguous instruction trials (for which they were required to make a decision between two potential referents), regardless of E1's action constraints, resulting in a main effect of instruction type. Additionally, if E1's action constraints served as a domain restriction for the ambiguous instruction trials, latency to object selection would be expected to decrease for the ambiguous hands-empty trials, but not for the ambiguous hands-full or either of the unambiguous instruction trials, resulting in an interaction between the two variables.

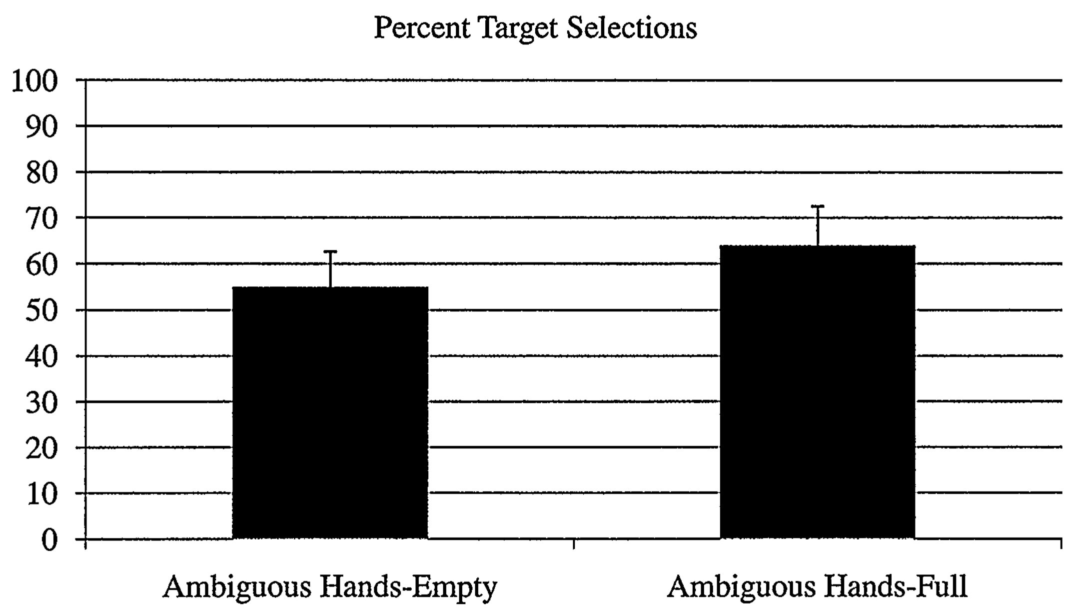
A 2 (ambiguous vs. unambiguous instruction) x 2 (hands-empty vs. hands-full) repeated-measures analysis of variance (ANOVA) yielded a significant main effect of instruction type, $F(1, 21) = 23.95$, $\eta_p = 0.53$, $p < .05$. Specifically, children responded significantly faster for the unambiguous instruction trials overall (M = 4464.41 ms, SD = 1978.52 ms) compared to the ambiguous instruction trials overall (M = 6780.39 ms, SD = 2500.37 ms). There was no main effect of hands, $F(1, 21) = 0.15$ $p > 0.05$, nor an interaction between instruction type and hands, $F(1, 21) = 0.26$, $p > 0.05$. Thus, the results indicate that children identified ambiguity when it was present but did not use information about the speaker's action constraints to resolve ambiguity faster during the ambiguous hands-empty trials.

Final Object Selections. For final object selections, I predicted children would be more likely to choose the target object for the ambiguous hands-empty instruction trials, and that they would select the target object at chance levels for ambiguous hands-full instruction trials.

A repeated-measures ANOVA compared the number of times the target object was chosen for the ambiguous hands-empty instruction trials to the number of times the target was chosen for the ambiguous hands-full instruction trials. The analysis revealed that children did not differ in their selections of the target object on the hands-empty trials (M = 54.76%, SD = 35.02%) versus on the hands-full trials (M = 64.29%, SD = 39.19%), $F(1, 21) = 0.718$, $p > 0.05$. Further, one-sample t-tests indicated that neither the target object selections in the ambiguous hands-empty trials or the ambiguous hands-full trials differed significantly from chance levels, *t* (21) = 0.295, p > 0.05 and *t* (21) = 1.312, p > 0.05, respectively. In other words, children selected between the target and referential alternative at chance, regardless of whether E1's hands were empty or full. See Figure 2.

Figure 2.

Percent of target object selections for ambiguous trials.



Discussion

The results of Experiment 1 indicate that, although 3-year-old children were aware of the referential ambiguity that was present during the ambiguous instruction trials, as reflected in their longer response latencies for ambiguous instruction trials, they did not use information about E1's action constraints to infer her communicative intentions. That is, children were just as likely to select the target object (the object out of E1's reach) when E1's hands were empty as they were to select the target object when her hands were full. However, it is possible that the placement of the reminder trials within the testing blocks provided some children (those who received a reminder trial at the beginning of the first test block) with an advantage over those who did not receive a reminder trial until later in the first testing block.

Therefore, in the next experiment, I explored whether older children would attend to E1's action constraints to resolve ambiguity in a similar task, but with a more extensive and explicit training phase introduced at the beginning of the experiment. In addition, the procedure was modified so that the reminder trials were presented to children exactly midway through each block of trials. Finally, I also wished to include eye gaze movements as a more sensitive measure of children's consideration of E1's action constraints.

Experiment 2

The purpose of Experiment 2 was threefold: First, to determine whether a training phase would highlight the potential use of a speaker's action constraints to infer the speaker's communicative intent; second, to test the new paradigm with older children, specifically 4-year-olds, as they have been shown to be better able to resolve communicative ambiguity than 3-year-olds (Berman et al., 2010); and third, to include eye gaze as a measure of children's implicit processing. The use of eye gaze measures in developmental research is beneficial both in that it places very low task demands on children, and can provide a more ecologically valid perspective on how children comprehend language (Fernald, Zangl, Portillo, & Marchman, 2008). That is, in real-world conversations with other people, we do not wait until a sentence is complete to interpret what the speaker has communicated. Rather, adult and child listeners constantly integrate information and interpret spoken language as it unfolds in real time (e.g., Tanenhaus, Spivey-Knowlton, Eberhard & Sedivy, 1995; Trueswell, Sekerina, Hill & Logrip, 1999). In addition, recent research conducted in our lab and elsewhere has suggested that young children may show evidence of certain referential communication abilities in eye gaze measures prior to demonstrating the abilities in their overt decisions (Nilsen, Graham, Smith & Chambers, 2008; Berman, Chambers & Graham, 2010; Nilsen & Graham, in press). Consequently, for a more sensitive measure of children's awareness of speaker action constraints, children's eye movements were analyzed for the ambiguous instruction trials.

Participants

Data from 19 4-year-olds were included in the final sample (10 girls, 9 boys; M = 57.18 months, SD = 3.05). An additional 8 children were tested but excluded from analyses due to a failure to scan the object array on at least three out of four ambiguous trials (n = 4), and experimenter error (n = 4). Children were recruited as in Experiment 1 and were given the same prizes for participation. Parents were given a follow-up letter describing the results of the study if they indicated that they were interested.

Materials

The set-up of the toy house described in Experiment 1 was the same in Experiment 2, but a Sony video camera was placed in the top middle compartment, covered except for a small opening to allow recording of the children's eye gaze. As in Experiment 1, twenty-four objects were used in Experiment 2: eight objects in the training phase, eight objects in the first testing block, and eight objects in the second testing block. Eight of the objects (four from the first testing block, and four from the second testing block) belonged to a pair but differed in color from one another. There was only one exemplar of each of the other sixteen objects. As none of the younger children in Experiment 1 had difficulty recognizing the ambiguity during the warm-up or test trials, in Experiment 2 I included only single objects in the training phase. Removing paired exemplars from the training phase allowed E1 to demonstrate which sides of the house she could/could not reach when her hands were empty and full, without coaching children as to which object of a pair to select when the instructions were ambiguous. See Table 3 for a list of the stimuli that were used in Experiment 2.

Procedure

Following the placement of the training objects in the house, E1 followed a dialogue (Appendix D) and demonstrated to the child that she could reach only the toys on the left side of the toy house ("Some of the toys I *can* reach…") and could not reach the toys on the right side of the house ("… and some of the toys I *can't* reach! Do you see? I can't reach the toys on that side of the house!"). E1 then picked up the backpack with both hands and explained that sometimes her hands would be full, and when her hands were full she could not reach *any* of the toys in the house. Children participated in eight training trials, four of which occurred with E1's hands being full, and four of which occurred with her hands being empty. Further, four of the training trials occurred with the object located in the experimenter's area, and four occurred with the object located in the participant's area. When E1's hands were empty and the object was located in her own area, she would say, "I'll get it!" and reached for it herself, placing it into the backpack. When E1's hands were empty but the object was located in the participant's area of the house, she would say, "I can't *reach* it!", and stretch her arm across the house to demonstrate that she was unable to reach the object. When E1's hands were full, she would say "I can't get it!", for all trials regardless of which area in the house the object was located. After completing the training trials, E1 pointed out that the child had a very good seat, because unlike E1, the child was able to reach *all* of the toys in the house.

Test phase. Immediately after the training phase, E2 placed the first set of test objects into the compartments. E1 again drew the child's attention to each object by naming the objects, one-by-one, as they were placed in the house. When the second item of a pair was placed into a compartment, E1 emphasized that the object was part of a pair (e.g., "Oh, and *another* horse!"). As in Experiment 1, six trials were conducted within each of the two testing blocks. Two of the trials within each block were *ambiguous instruction* trials, two of the trials were *unambiguous instruction* trials, and two of the trials were *reminder* trials (identical to the reminder instruction trials in Experiment 1), for which E1 verbally and visually reminded the child what had already been taught in the training phase (i.e., what she could and could not reach in the house). However, in Experiment 2, the reminder trials were *always* the third and fourth of the six instructions in each testing block. For the two ambiguous, two unambiguous, and two reminder trials in each testing block, E1's hands were empty for one trial and full (i.e., holding the backpack with both hands) for the other.

The script and procedure for the two testing blocks remained the same as in Experiment 1, except for the placement of the reminder instruction trials as described above.

Coding

Recall that latency to object selection was used to establish whether or not children were sensitive to the ambiguity present in the ambiguous instruction trials and the speaker's action constraints, and the coding procedure was the same as in Experiment 1. A second research assistant coded five randomly selected participants (26% of the sample) to provide a measure of inter-rater reliability. The ICC coefficient for latency to object selection indicated a sufficient level of inter-rater reliability, ICC (39) = .99, $p < .001$.

Next, children's eye gaze movements were coded to test for a more implicit awareness of ambiguity and speaker action constraints. Children's eye movements were coded beginning with the onset of the noun and ending when the child touched an object in the house (determined using the scene camera recordings). Videos were analyzed on a frame-by-frame basis (33 ms = 1 frame) in FinalCut Pro 5.0.4, with audio and video signals fully synchronized. Again, the referent

Table 3.

Stimuli for Experiments 2 and 3.

Phase	Instruction Type	Referent 1	Referent 2
Training	Training	Red Car	
	Training	Yellow Fork	
	Training	Toothbrush	
	Training	Airplane	
	Training	Plastic Orange	
	Training	Crayon	
	Training	Plastic Grapes	
	Training	Red Flower	
Testing Set 1	Ambiguous	Light Brown Horse	Dark Brown Horse
	Ambiguous	Pink Book	Blue Book
	Unambiguous	Rubber Duck	
	Unambiguous	Plastic Cup	
	Reminder	Plastic Apple	
	Reminder	Cat	
Testing Set 2	Ambiguous	Brown Cow	Black Cow
	Ambiguous	Red Spoon	Yellow Spoon
	Unambiguous	Wooden Chair	
	Unambiguous	Dog	
	Reminder	Elephant	
	Reminder	Infant Shoe	

in the participant's area was always considered the *target* object, and the other toy from the pair in the experimenter's area was always considered the *referential alternative*. The ICC coefficient for eye gaze movements indicated a satisfactory level of inter-rater reliability for time spent looking to the target object, ICC (39) = .99, $p < .001$ and time spent looking to the referential alternative, ICC (39) = .99, $p < .001$.

Finally, children's final object selections were used as an indicator of their overt ability to attend to the speaker's action constraints and resolve ambiguity. As in Experiment 1, we expected that children would select the target object more often when E1's hands were empty, and would select between the target and referential alternative at chance when E1's hands were full. Final object selections were coded by E2 during the experiment, but were always re-coded by the primary coder. There was 100% level of agreement between E2 and the primary coder in terms of the objects that children selected, resulting in a Cohen's kappa coefficient of 1.00.

Results

Latency to Object Selections. A 2 (ambiguous vs. unambiguous instruction) x 2 (hands-empty vs. hands-full) repeated-measures ANOVA indicated a main effect of instruction type, in that children took significantly less time to respond to unambiguous instruction trials (M = 3588.20 ms, SD = 1028.90 ms) as compared to ambiguous instruction trials (M = 4707.28 ms, SD = 1656.56 ms), F (1, 18) = 28.709, $\eta_p = 0.62$, $p < 0.05$. These results indicate that children recognized the presence of ambiguity during the *ambiguous instruction* trials. There was no main effect of E1's hands being empty versus full, F (1, 18) = 1.748, $p > 0.05$ and no interaction between instruction type and hands, F (1, 18) = 0.010, $p > 0.05$. Thus, contrary to my hypothesis, information about the speaker's action constraints did not help children resolve the ambiguity faster in the ambiguous hands-empty trials versus the hands-full trials.

Eye Gaze Data. I expected that for *ambiguous instruction* trials children would spend a greater proportion of time looking to the target object (i.e., the object in the participant's area) versus the referential alternative (i.e., the object in the experimenter's area) when E1's hands were empty, but consider the target and referential alternative equally when E1's hands were full. That is, if 4-year-olds used speaker action constraints to guide their inferences about communicative intent, they would be more likely to assume that E1 intended to refer to the referent that she could not reach herself (i.e., the target object) when her hands were empty. Conversely, children should have been more likely to consider the object within E1's reach (i.e., the referential alternative) when E1's hands were full.

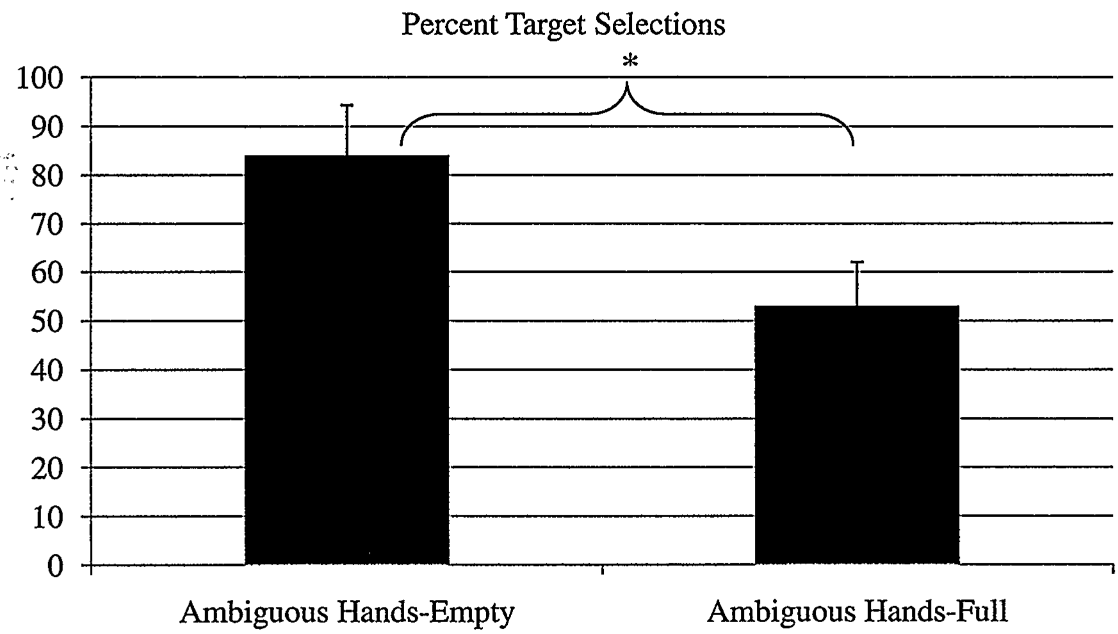
Children's looking time to the target was converted to proportion scores by dividing the looking time to the target quadrant by the total looking time overall. Planned paired-samples t-tests revealed that, during the ambiguous hands-empty instruction trials, children spent a significantly greater proportion of time looking to the target object ($M = 0.51$, $SD = 0.20$) than they did looking to the referential alternative ($M = 0.30$, $SD = 0.19$), t (18) = 2.62, $p < 0.05$. During the ambiguous hands-full trials, however, children's proportion of time looking to the target object ($M = 0.47$, $SD = 0.23$) did not differ significantly from their consideration of the referential alternative ($M = 0.36$, $SD = 0.23$), t (18) = 1.05, $p > 0.05$. These results demonstrate that 4-year-olds were more likely to consider the referential alternative as a potential referent when information about E1's action constraints was not a helpful cue to communicative intent (i.e., E1's hands were full and she could not reach either of the potential referents).

The eye gaze data also allowed for the assessment of whether the 4-year-olds used information about the speaker's action constraints early in processing the instruction, as has been found with adults (Hanna & Tanenhaus, 2004). Thus, children's first looks after the onset of the noun were analyzed for the *ambiguous instruction* trials to see whether 4-year-olds were more likely to look to the participant's area of the house (i.e., where the target was located) immediately after onset of the noun when E1's hands were empty versus when her hands were full. A planned paired-samples t-test indicated that children were just as likely to make their first look towards the participant's area for ambiguous hands-empty trials (*M* = 53%, *SD* = 35%) as they were for ambiguous hands-full trials (*M* = 47%, *SD* = 42%), $t\ (18) = 0.42$, $p > 0.05$, suggesting that the domain restriction was not immediate.

Final Object Selections. A repeated-measures ANOVA was performed in which the number of times the target object was selected in the ambiguous hands-empty trials was compared to the number of times the target object was selected in the ambiguous hands-full trials. 4-year-old children picked the target object significantly more often in the ambiguous hands-empty trials (*M* = 84%, SD = 29%) than in the ambiguous hands-full trials (*M* = 53%, *SD* = 39%), $F\ (1, 18) = 13.09$, $\eta_p = 0.42$, $p < 0.05$. Furthermore, one-sample t-tests revealed that the percentage of target object selections was significantly greater than chance (50%) on the ambiguous hands-empty trials, $t\ (18) = 5.12$, $p < 0.05$ but did not differ from chance on the ambiguous hands-full trials, $t\ (18) = 0.294$, $p > 0.05$. The results indicate that 4-year-olds were able to use the speaker's action constraints to infer her communicative intent and make a final referential decision. See Figure 3.

Figure 3.

4-year-olds' percent of target object selections for ambiguous trials.



Discussion

The results of Experiment 2 indicate that, when provided with an explicit training phase, 4-year-old children used knowledge about a speaker's action constraints to infer communicative intent and resolve referential ambiguity. More specifically, children were significantly more likely to visually consider and then explicitly select the referent that the speaker could not retrieve herself (i.e., the target object) when her hands were empty compared to when her hands were full. In addition, the results of Experiment 2 demonstrated that children's integration of speaker action constraints into their referential decision making process did not happen immediately upon hearing the noun, as has been shown with adults (Hanna & Tanenhaus, 2004). Rather, it seems as though 4-year-old children consider this information at some point later in sentence processing. However, due to the limitations of using what has been affectionately referred to in the literature as the "poor-man's eyetracker" (Trueswell, 2008), the present study is unable to pinpoint at exactly which point in processing this information is integrated.

In the next study, I explored whether even younger children could use a speaker's action constraints to infer communicative intent and resolve referential ambiguity.

Experiment 3

As Experiment 2 illustrated that 4-year-olds were able to infer a speaker's communicative intent based on her action constraints, the purpose of Experiment 3 was to return to an examination of 3-year-olds' ability to use this cue with the addition of the training phase and more sensitive eye gaze measures.

Participants

Data from 20 3-year-olds were included in the final sample (9 girls, 11 boys; $M = 44.04$ months, $SD = 4.08$). An additional 6 children were tested but excluded from analyses for the following reasons: judged to be statistical outliers (i.e., having a z-score of +/- 3.00) on two or more critical variables (n = 1) or a failure to scan the object array on at least three out of four ambiguous trials (n = 5). Children were recruited as in Experiments 1 and 2, and were given the same prizes for participation. Parents were given a follow-up letter describing the results of the study if they indicated that they were interested. None of the 3-year-olds in Experiment 3 had participated in Experiment 1.

Materials

The materials used for Experiment 3 were identical to those used in Experiment 2.

Procedure

The procedure followed in Experiment 3 was the same as the procedure for Experiment 2.

Coding

The coding procedure for Experiment 3 was the same as for Experiment 2. To establish inter-rater reliability for latency and eye gaze data, 5 randomly selected videos (25% of the sample) were re-coded by a second coder. The ICC coefficients indicated a good level of inter-rater reliability for all variables, ICC (39) = .92, $p < 0.001$ for latency to object selection, ICC (39) = .98, $p < 0.001$, for total looking time to the target, and ICC (39) = .99, $p < 0.001$ for total looking to the referential alternative. There was 100% level of agreement regarding children's final object selections, resulting in a Cohen's kappa coefficient of 1.00.

Results

Latency to Object Selections. A 2 (ambiguous vs. unambiguous instruction) x 2 (hands-empty vs. hands-full) repeated-measures ANOVA indicated a main effect of instruction type. Children took significantly less time to respond to *unambiguous instruction* trials (M = 3350.04 ms, SD = 651.41 ms) as compared to *ambiguous instruction* trials (M = 4355.74 ms, SD = 890.41), F (1, 19) = 16.06, $\eta_p = 0.46$, $p < 0.05$, suggesting that they recognized the presence of ambiguity during *ambiguous instruction* trials. There was no main effect of E1's hands being empty versus full, F (1, 19) = 2.36, $p > 0.05$ and no interaction between instruction type and hands, F (1, 19) = 1.62, $p > 0.05$. Thus, as with the previous two experiments, information about the speaker's action constraints did not help 3-year-olds resolve ambiguity faster, even when the action constraint provided a cue to communicative intent (i.e., the ambiguous hands-empty trials).

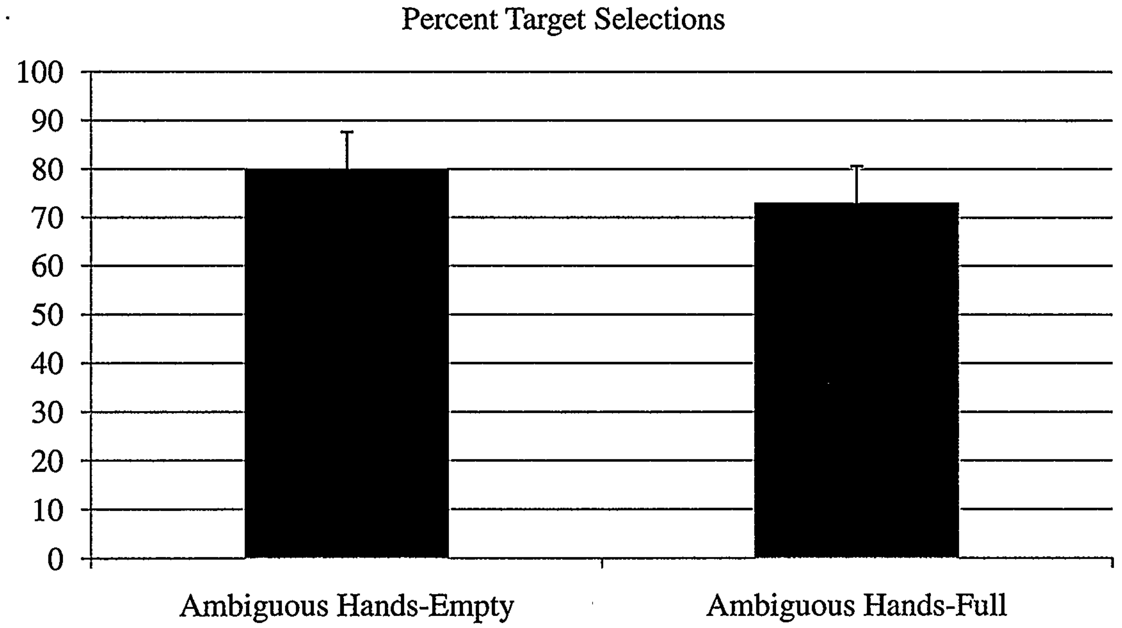
Eye Gaze Data. Planned paired-samples t-test revealed that, during the ambiguous hands-empty trials, 3-year-old children spent a significantly greater proportion of time looking to the target object (M = 0.52, SD = 0.19) than they did looking to the referential alternative (M = 0.24, SD = 0.15), t (19) = 4.01, $p < 0.05$. During the ambiguous hands-full trials, however, children did *not* spend a significantly greater proportion of time looking to the target object (M = 0.49, SD = 0.22) compared to the referential alternative (M = 0.32, SD = 0.21), t (19) = 1.75, $p > 0.05$. Thus, when the speaker's hands were empty, 3-year-old children used this information to infer that she intended to refer to the object that was out of her reach.

For the first look data, paired-samples t-test indicated that 3-year-olds, like 4-year-olds, were just as likely to make their first look to the participant's area for ambiguous hands-empty trials (*M* = 57%, *SD* = 43%), as they were for the ambiguous hands-full trials (*M* = 52%, *SD* = 38%), t (19) = 0.37, $p > 0.05$. The results indicate that 3-year-old children's appreciation for speaker action constraints as a cue to communicative intent, although evidenced in their eye gaze movements, did not occur immediately in processing.

Final Object Selections. A repeated-measures ANOVA comparing the percent of target selections for ambiguous hands-empty trials (*M* = 80%, *SD* = 34%) versus ambiguous hands-full trials (*M* = 73%, *SD* = 34%) revealed no significant difference between the two trial types, F (1, 19) = 0.68, $p > 0.05$. Additionally, one-sample t-tests indicated that the percent of target object selections was significantly above chance level for both the ambiguous hands-empty trials, t (19) = 3.94, $p < 0.05$, and ambiguous hands-full trials, t (19) = 2.93, $p < 0.05$. That is, children demonstrated a general preference for the object that E1 could not reach (i.e., the target), and selected that object at above chance levels, regardless of whether E1's hands were empty or full. These findings reveal that even with the addition of a training phase, appreciation for speaker action constraints was not evident in 3-year-olds' explicit referential decisions. See Figure 4.

Figure 4.

3-year-olds' percent of target object selections for ambiguous trials.



Discussion

In Experiment 3, 3-year-olds displayed an overall preference to select the target object, regardless of whether E1's hands were empty or full. At first, these findings seem to suggest that children did not use information about speaker action constraints to infer communicative intentions and make their referential decisions. However, the eye gaze data revealed a more implicit appreciation for this cue, reflected in decreased looking time to the referential alternative when E1's hands were empty, and increased looking time to the referential alternative when E1's hands were full. Thus, although 3-year-old children are beginning to show an understanding of speaker action constraints, this did not translate into their explicit referential decisions.

General Discussion

The purpose of these studies was to evaluate children's ability to integrate information from the broader communicative context to infer a speaker's communicative intentions. More specifically, I examined whether children would use a speaker's action constraints when interpreting an ambiguous instruction. To address this research question, I analyzed 3- (Experiments 1 and 3) and 4-year-olds' (Experiment 2) performance without explicit training (Experiment 1) and with explicit training (Experiments 2 and 3), on a task in which they were faced with referential ambiguity. Children were seated before an array of various toys, some of which were part of a pair. The experimenter then asked each child to assist her in packing a backpack with toys, which she requested one at a time. The trials varied in terms of whether the instruction was ambiguous (i.e., referenced more than one potential referent) or unambiguous (i.e., referenced only one referent), and whether the experimenter's hands were empty or full at the time of the request. When the instruction was ambiguous, children had to make an inference about the speaker's communicative intention in order to select an object to put in the backpack. Importantly, the design of the study ensured that children resolved the referential ambiguity in the absence of any cues to communicative intention, aside from the speaker's action constraints.

The results from these experiments provide several insights into young children's ability to employ information from the broader communicative context to infer a speaker's communicative intent. First, 4-year-olds, but not 3-year-olds, showed explicit evidence of using speaker action constraints when interpreting referential ambiguity. Second, a discrepancy between 3-year-old children's explicit decisions and their implicit processing was apparent when eye gaze measures were incorporated into Experiment 3. That is, 3-year-olds' eye-movements suggested an understanding of speaker action constraints, even though their object selections did not reveal sensitivity to this cue. Finally, these three studies highlight children's ability to draw on progressively more complex cues to the communicative intentions of others.

To begin, children's object selections indicated that 4-year-old children used information about a speaker's action constraints to infer the speaker's communicative intention. That is, when the speaker made an ambiguous request (i.e., asked for an object in the presence of two equally plausible referents) and her hands were empty, 4-year-olds selected the target object (the object out of the speaker's reach) significantly more often than they did when the speaker's hands were full. Thus, when the speaker's hands were empty, 4-year-olds inferred that her intention was to indicate the referent that she could not reach; when the speaker's hands were full, however, children broadened their consideration to include both referents, as the speaker could no longer reach either. Three-year-old children, on the other hand, selected the target object above chance for the ambiguous instructions when the speaker's hands were empty *and* when they were full. These findings suggest that 3-year-old children did not use the speaker's action constraints to discriminate between contexts in which the speaker would be referring to an object that she could not retrieve herself (hands-empty) and contexts in which the speaker could be referring to either object due to her own action constraints (hands-full).

The second insight provided by this study is that children's eye gaze patterns suggest some appreciation for speaker action constraints as early as 3-years of age. That is, on the ambiguous instruction trials, both 3- *and* 4-year-olds spent a significantly greater proportion of time looking at the target object than at the referential alternative when the speaker's hands were empty versus when her hands were full. Thus, the eye gaze data suggested that children in both age groups recognized that the speaker's empty hands could be used as a cue to her communicative intention, in that the speaker would not intend to refer to an object that she could obviously retrieve herself. When the instruction was ambiguous and the speaker's hands were full, however, both 3- and 4-year-olds spent roughly equal proportions of time looking to the target and referential alternative, as the speaker's additional action constraint (full hands) meant that both referents were equally plausible.

The dissociation between 3-year-olds' object selections and eye gaze movements is consistent with previous findings suggesting that many cognitive abilities are apparent in more sensitive measures of implicit understanding prior to becoming apparent in children's overt decisions (Berman et al., 2010; Garnham & Ruffman, 2001; Nilsen & Graham, in press; Nilsen et al., 2008; Plumert, 1996). For example, Garnham and Ruffman (2001) found that 3- and 4-year-olds showed understanding of a story character's belief in their anticipatory eye gaze movements before they could show the same understanding in their verbal predictions. Similarly, Nilsen et al. (2008) demonstrated that even though 4-year-old children's explicit decisions suggested that they judged an ambiguous message to be unambiguous for another person, they showed implicit awareness of message ambiguity in their eye gaze movements and selection latencies. The results of the present study suggest a similar developmental pattern in terms of children's appreciation for speaker action constraints as a cue to communicative intent. More specifically, results suggest that even 3-year-olds are implicitly aware that a speaker's communicative intentions can be inferred from cues in the broader communicative context, such as what that speaker is able or unable to do in a given task.

What might account for the discrepancy between 3-year-olds' processing, as measured by their eye gaze, and their explicit referential decisions, as measured by their object selections? Given that 3-year-old children's looking patterns suggest that their failure to use the speaker's action constraints in their explicit decisions was not due to a failure to comprehend or recall the speaker's action constraints, the issue was likely in terms of applying that knowledge to make a decision. Following from this, 3-year-old children's lack of an explicit awareness of speaker action constraints is not surprising given the complexity of the task. First, children had to survey the overall scene, process and then remember which areas of the toy house only *they* could reach and which areas of the toy house the experimenter could *also* reach. Second, children had to listen to and process the information that was presented to them by the speaker at the beginning of each trial regarding her ability to use her hands (e.g., "[Child's name], look at me! My hands are empty!"). Then, children had to hold this information in mind while the experimenter provided the actual instruction (e.g., "Spot wants the book. Put the book in the backpack.") Furthermore, when the object that was requested belonged to a pair, children were required to recognize the ambiguity in the utterance in order to identify the need to make an inference about the speaker's communicative intention. Finally, children had to determine whether the information about the speaker's action constraints, presented at the beginning of the trial, could be used for the purpose of identifying her communicative intention (i.e., which of two plausible referents she meant to request). In fact, information about the speaker's action constraints was only helpful some of the time, as the unambiguous instruction trials did not require any extra-linguistic information in order to make a successful interpretation. Thus, upon realizing that the speaker's action constraints were irrelevant in some of the trials, 3-year-old children may have subsequently disregarded the cue and instead just selected the item that the speaker could never reach; this would explain 3-year-old's preference for the target object. With these steps in mind, it is easier to appreciate how difficult this task would be for children and why they might have difficulty explicitly displaying their knowledge at such a young age.

A second potential explanation for the discrepancy between 3-year-olds' implicit and explicit awareness relates to children's assumptions about the cooperativeness of their communicative partners. According to Speer (1984), young children use a two-step strategy to interpret ambiguous instructions. First, children exploit various cues in the context to determine the speaker's communicative intention. When and if that strategy fails, Speer proposed that children simply guess the correct response and assume correctness until the communicative partner repairs the interpretation, as a cooperative partner would. In the present study, it is possible that the context of the communicative interaction failed to provide the standard cues that children are used to receiving from others (e.g., eye gaze, gestures, etc.). If awareness of speaker action constraints is still tenuous at this age, as it appears to be, then 3-year-olds may have concluded that the context did not provide enough information. They may have then guessed the speaker's intention and inferred that the referent of the ambiguous instruction was the object that the experimenter could never reach. Children may have interpreted the lack of corrective feedback as indication that they had responded correctly, and thereafter relied on the guessing strategy.

The results of the present experiments contribute to a growing body of research demonstrating that young children draw on a multitude of cues to infer the communicative intentions of others. Considering the ubiquity of ambiguity in communication, it may not be surprising that children are skilled at extracting information from the communicative context, as has been demonstrated in the word learning literature. The present study adds to this research by investigating children's use of cues to communicative intention for familiar yet ambiguous language. Indeed, children appear to become increasingly capable of inferring the intentions of others – first recognizing the intentionality of actions (e.g., Woodward, 1998), then inferring referential intentions word learning (e.g., Baldwin, 1993), and eventually engaging in more complex inferential processes as required to resolve ambiguity in the presence of familiar language (e.g., Berman et al., 2010). As children refine their ability to infer communicative intentions, their use of contextual cues expands and begins to include cues that may be less directly implicated in the communicative situations, such as the actions available to a speaker. The present study demonstrates that, sometime during the preschool period, speaker action constraints become part of this repertoire of cues that children use to infer communicative intentions.

Despite the utility of speaker action constraints to infer communicative intention in experimental settings, it remains to be determined how children and adults might use information about speaker action constraints in natural communicative contexts. Ordinary communicative contexts are obviously much different from those created for experimental purposes, in that listeners are exposed to more than one cue to the speaker's communicative intention and do not receive explicit preparation. Recall that the procedure for Experiments 2 and 3 included an explicit training phase in which E1 demonstrated that (a) when her hands were empty she could only reach objects in the experimenter's area, (b) when her hands were full she could reach none of the objects, and (c) the participant could reach *all* of the objects. Even the adults in the study by Hanna and Tanenhaus (2004) were given explicit training prior to performing the task: two practice trials to demonstrate the experimenter's action constraints, and the specific instruction that throughout the task participants "would have to help [the experimenter] out either by moving the objects that [the experimenter] couldn't reach or by moving one of [the experimenter's] own objects if she couldn't do it herself" (p. 109). Thus, future research could begin to examine the utility of this cue in more natural communicative contexts, which will likely be made possible with the development of more mobile and less intrusive eye-tracking systems.

Finally, two limitations to the present study should be discussed. First, children not following a typical pragmatic developmental trajectory may have inadvertently been included in my sample. A measure of general pragmatic competence was not included in the measures, but would be an interesting avenue for future research. A second limitation of this study is that my ability to detect where children were looking within a given quadrant was limited, due to the use of a video camera eye-tracker. The video camera eye-tracking allowed coders to code which quadrants, but not which specific objects, the child looked at during each trial; this is obviously a more unrefined measure of looking behaviour than would be possible with a remote or head-mounted eye-tracking system. However, video camera eye-trackers permit children to move their heads without a significant loss of coding accuracy (Trueswell, 2008). The flexibility for head movement was necessary for this study, because the task required children to physically retrieve objects, unlike other experiments that require children to just look or point at the referents. In addition, differentiating between looks to the four quadrants was easily manageable using the video camera eye-tracking method. Further, as children never selected the wrong referent for any of the trials, I was able to be quite confident that looks to the quadrant of a particular object in fact indicated looks to that object. However, this limitation points to an avenue for future research, including the development of a task in which a remote eye-tracking system could be used to glean more fine-grained information from children's eye movements.

In summary, the results of these studies offer insight into an important aspect of children's communicative competence: the ability to extract information from the broader communicative context and use that information to deduce a speaker's intention. The findings have demonstrated that both 3- and 4-year-olds have an implicit sensitivity to speaker action constraints, but only 4-year-olds use this information to make their explicit referential decisions. Together, the results demonstrate a developmental progression in terms of children's appreciation for speaker action constraints as a cue to communicative intent. Specifically, 3-year-olds' implicit awareness of speaker action constraints as a cue to communicative intent may be a precursor to 4-year olds' ability to use this information to make explicit referential decisions, followed by the much more immediate use of speaker action constraints demonstrated by adults (Hanna & Tanenhaus, 2004).

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Appendix A

Consent Form

Informed Consent Form: Parents

Title of Project: Children's Use of Speaker-Based Cues to Resolve Ambiguity

Researcher: Sarah Collins and Susan Graham, Ph.D.

Funding Agency: SSHRC

This consent form, a copy of which has been given to you, is only part of the process of informed consent. If you would like more details about something mentioned here, or information that is not included here, you should feel free to ask. Please take the time to read the consent form carefully and to understand any accompanying information.

The University of Calgary Conjoint Faculties Research Ethics Board has approved this research study.

Purpose of the Study:

The goal of the study is to examine whether young children are able to use speaker-based cues to resolve ambiguity. In the context of this study, ambiguity occurs when the speaker requests that the child select a particular object (e.g., "Hand me the cup") although there are two possible referents (i.e., there are two cups in an array of toys). When there are two potential referents, one will be within the speaker's reach, and the other will be out of the speaker's reach but within the reach of the child.

We are interested in whether a speaker's ability to reach objects influences how children resolve ambiguity. If children are attending to a speaker's reaching ability, children may hold different expectations about the speaker's intent depending on whether the speaker's hands are empty or full when she makes the ambiguous request. Specifically, if the speaker's hands are *empty* when the child is asked to select the object (e.g., the cup), the child may expect that the speaker is referring to the cup that is *out* of the speaker's reach. In other words, the child may assume that if the speaker wanted the cup that is within her own reach, she would get it herself. Conversely, when the speaker's hands are *full* (i.e., she cannot reach *either* of the cups), the statement may become more ambiguous and the child may take longer to decide which cup the speaker is referring to.

What Will My Child Be Asked To Do?

A researcher will sit your child in front of a large toy house. The house will be filled with objects (e.g., a cup, a toy horse). Sometimes there will be duplicates of objects, one within the researcher's reach and one outside of her reach. The researcher will sit beside your child and will request that the child help her fill a backpack with some of the toys. While requesting an object, the experimenter will either have her hands full (i.e., holding the backpack) or empty. There will be a training phase consisting of 8 trials, and then 12 testing trials. Your child will spend approximately 10 minutes in the testing room.

The session will be videotaped for coding purposes only. You and your child's participation is entirely voluntary and you or your child have the right to refuse participation at any time

What Type of Personal Information Will Be Collected?

If you choose to participate you will be asked to provide your child's full name, birthdate, gender and some information about your child's vocabulary.

What Happens to the Information I Provide?

All collected information is anonymous and confidential. Children's responses will be identified using an assigned participant number and not the name of your child. Only the research team will have access to the videotapes of your child's participation.

If you have any questions regarding this research, please to not hesitate to ask.

If participation is discontinued, any collected information will be destroyed and not used in any analyses.

Signatures (written consent)

Your signature on this form indicates that you (1) understand to your satisfaction the information provided to you about your participation in this research project, and (2) agree to participate as a research subject.

In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from this research project at any time. You should feel free to ask for clarification or new information throughout your participation.

Child's Name: (please print) ____

Parent's or Guardian's Name: (please print) ____________________________________

Parent's or Guardian's Signature: ________________________________ Date: _________

Researcher's Name: Sarah Collins

Researcher's Signature: ____

Questions/Concerns

If you have any further questions or want clarification regarding this research and/or your participation, please contact:

Dr. Susan Graham, Ph.D.
Associate Professor of Psychology
Department of Psychology, Faculty of Social Science, University of Calgary
Tel: (403) 220-7188, grahams@ucalgary.ca

If you have any concerns about the way you've been treated as a participant, please contact Russell Burrows, Research Services Office, University of Calgary at (403) 220-3782; email rburrows@ucalgary.ca.

A copy of this consent form has been given to you to keep for your records and reference. The investigator has also kept a copy of the consent form.

Appendix B

Dialogue for Experiment 1

<u>Introduction</u>
Ok [child's name]. We're going to play some games together with "Spot" the dog!

We're going to play with this house (*point at house*). [E2] is going to put some different things on the shelves here (*tap shelves*) and this camera (*point at camcorder*) is going to take pictures of you. Let's see if [E2] can see you in the camera!

- Can see: "Great! I can see you really well when you're sitting up straight like that."
- Cannot see: "I can't see you… Can you sit straight up in your chair? Great! That's perfect now!"

Now, Spot the dog is going on a trip to play at a friend's house. He really wants to bring some of his toys to show his friend. He has a backpack, and we are going to help him pack some toys from inside the house.

<u>Warm-Up Trials</u>
E2 fills house with trial objects.

When I ask you to, you will help me get things from inside the house. Some things I can reach myself (*pick up toy from [EXP] side*), and some things I can't reach (*try to reach across the house*)! Do you see? I can't reach the toys on that side. Now, (child's name), sometimes my hands are full and I can't reach *any* of the toys. Do you see? My hands are full and I can't reach any of the toys!

Before we start, let's see if *you* can reach all of the toys and help me fill Spot's backpack!

<u>Warm-up Trial 1</u>: "<u>(Child's name)</u>, can you point to the two *cars* in the house?
- Correct: "Good! I can reach this car (*pick up car from EXP side*), but I can't reach the other one. Put the other car in Spot's backpack!"
- Incorrect: "There are two cars in the house. I can reach this car (*pick up car from EXP side and put in bag*), and one is on the other side. I can't reach that one. Put the other car in Spot's backpack!"

<u>Warm-up Trial 2</u>: "<u>(Child's name)</u>, can you point to the two *forks* in the house?
- Correct: "Good! I can reach this fork (*pick up fork from EXP side*), but I can't reach the other one. Put the other fork in Spot's backpack!"
- Incorrect: "There are two forks in the house. I can reach this fork (*pick up fork from EXP side and put in bag*), and one is on the other side. I can't reach that one. Put the other fork in Spot's backpack!"

Wow, you have a *really* good seat, don't you? You can reach all the toys in the house!

Test Trials

Testing Block 1
E2 places the first set of 8 test objects in the house.

Make sure you don't touch the toys until Spot asks, because we don't know which ones he wants! (*Repeat as necessary*). Now let's help Spot fill his backpack with his toys!

[Child's name], look at me! My hands are [full / empty]! Now look back to the smiley face! Spot wants the [object name].

- Ambiguous and Unambiguous Instruction Trials: "Put the [object name] in the backpack!"
- Reminder Instruction Hands-Empty Trials: "I'll get it!"
- Reminder Instruction Hands-Full Trials: "I can't get it!"

[Repeat for all six trials in first testing block]

Spot doesn't want any more of *these* toys for his backpack (*E2 removes remaining objects*). But he has some other toys to pick from too. Let's see what other toys Spot has!

Testing Block 2
E2 places second set of 8 objects in the house.

Remember, you have to wait until Spot tells you what toys he wants for his backpack. Let's help Spot fill his backpack with his toys!

[Child's name], look at me! My hands are [full / empty]! Now look back to the smiley face! Spot wants the [object name].

- Ambiguous and Unambiguous Instruction Trials: "Put the [object name] in the backpack!"
- Reminder Instruction Hands-Empty Trials: "I'll get it!"
- Reminder Instruction Hands-Full Trials: "I can't get it!"

Repeat for all six trials in second testing block.

Appendix C

Dialogue for Experiments 2 and 3

Introduction

"Ok [child's name]. We're going to play some games together with "Spot" the dog.

"We're going to play with this house (point at house). [E2] is going to put some different things on the shelves here (tap shelves) and this camera (point at camcorder) is going to take pictures of you. Let's see if [E2] can see you in the camera!"

- Can see: "Great! I can see you really well when you're sitting up straight like that."
- Cannot see: "I can't see you... Can you sit straight up in your chair? Great! That's perfect now!"
-

"Now, Spot the dog is going on a trip to play at a friend's house. He really wants to bring some of his toys to show his friend. He has a backpack, and we are going to help him pack some toys from inside the house."

Warm-up

[E2] fills house with trial objects.

"When I ask you to, you will help me get things from inside the house. Some things I can reach myself (pick up toys from [EXP] side), and some things I can't reach (try to reach across the house)! Do you see? I can't reach the toys on that side of the house. Sometimes my hands are full and I can't reach *any* of the toys. Do you see? My hands are full and I can't reach any. *Most of the time* you'll help me get things from that side of the house, because I can't reach them. But *sometimes* when my hands are full, you'll help me get things from this side of the house."

"Before we start, let's practice putting some toys in Spot's backpack!"

"(Child's name), look at me! My hands are EMPTY. Spot wants the CAR. I'll get it!"

"(Child's name), look at me! My hands are FULL. Spot wants the FORK. I can't get it!"

"(Child's name), look at me! My hands are EMPTY. Spot wants the TOOTHBRUSH. I can't *reach* it!"

"(Child's name), look at me! My hands are FULL. Spot wants the CRAYON. I can't get it!"

"(Child's name), look at me! My hands are EMPTY. Spot wants the ORANGE. I'll get it!"

"(Child's name), look at me! My hands are FULL. Spot wants the AIRPLANE. I can't get it!"

"(Child's name), look at me! My hands are EMPTY. Spot wants the FLOWER. I can't *reach* it!"

"(Child's name), look at me! My hands are FULL. Spot wants the GRAPES. I can't get it!"

Test Trials

Testing Block 1
E2 places the first set of 8 test objects in the house.

Make sure you don't touch the toys until Spot asks, because we don't know which ones he wants! (*Repeat as necessary).* Now let's help Spot fill his backpack with his toys!

[Child's name], look at me! My hands are [full / empty]! Now look back to the smiley face! Spot wants the [object name].

- Ambiguous and Unambiguous Instruction Trials: "Put the [object name] in the backpack!"
- Reminder Instruction Hands-Empty Trials: "I'll get it!"
- Reminder Instruction Hands-Full Trials: "I can't get it!"

[Repeat for all six trials in first testing block]

Spot doesn't want any more of *these* toys for his backpack (*E2 removes remaining objects*). But he has some other toys to pick from too. Let's see what other toys Spot has!

Testing Block 2
E2 places second set of 8 objects in the house.

Remember, you have to wait until Spot tells you what toys he wants for his backpack. Let's help Spot fill his backpack with his toys!

[Child's name], look at me! My hands are [full / empty]! Now look back to the smiley face! Spot wants the [object name].

- Ambiguous and Unambiguous Instruction Trials: "Put the [object name] in the backpack!"
- Reminder Instruction Hands-Empty Trials: "I'll get it!"
- Reminder Instruction Hands-Full Trials: "I can't get it!"

Repeat for all six trials in second testing block.