Infants' understanding of the goal-directed nature of walking:

Does action production facilitate action perception?

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Abstract

Adults are adept at seeing beyond the simple surface characteristics of others' behavior to interpret underlying beliefs, desires, and intentions. To date, much prior research has attempted to trace the origins of theory of mind in infancy, particularly infants' understanding of others' goal-directed behavior. In this study, a demonstrator modeled a previously unexplored, "macro" human behavior—walking—in order to explore whether it is appreciated as goal-directed among infants. This contrasts with previous research, which has focused on "micro" behaviors such as reaching and grasping. In addition to identifying a new behavior perceived as goal-directed early in life, this project also serves as evidence in the inquiry as to the mechanism by which infants acquire goal-directed behavioral understanding in others. Recent research suggests that infants' own experience with and mastery of behaviors allows for an understanding of the same behaviors when performed by other people. This study tested the self-experience hypothesis by examining the understandings of separate groups of infants who could and could not yet walk. Results did not support the research hypothesis that walkers are capable of perceiving another's walking as goal-directed. The discussion focuses on study limitations that may have caused the null findings.

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A museum-goer shuffles his feet around the perimeter of a room, pausing beside several paintings and sculptures. A customer extends her index finger over a counter toward a display of cigarettes. A golfer orients his head toward his club bag and reaches for the 8-iron. To the layperson and the psychologist alike, mere physical descriptions of human behavior do not capture the full account of what is taking place in events such as those presented. The museum-goer approached the artwork he thought was interesting for further exploration. The customer communicated her desire to obtain her favorite brand of cigarettes. And the golfer planfully selected the club he believed would lead to a successful shot. The attribution of mental states such as desires, thoughts, and beliefs help disambiguate human behavior. But, paradoxically, the knowledge of one's own and other's mental states, called theory of mind, cannot be directly observed and must instead be inferred (Bretherton & Beeghly, 1982).

Again, the importance of theory of mind for humans cannot be understated. Such understanding allows for complex social behaviors. This is quite evident in the realms of sports and games. The game of poker is challenging because the player must simultaneously be "reading" her opponents while simultaneously not "telling" her own intentions. Conversely, teamwork requires players to share a common goal in sports from basketball to water polo. Not only does each player need to know the team's goal and the means by which to achieve it, he needs to know that his teammates know that he knows this, too! If this understanding is not in place, players are "not on the same page," and their collaborative efforts fail. This teamwork example is what Tomasello and Carpenter (2007) would call shared intentionality. They argue that the uniquely human ability to engage in shared intentionality is what has allowed our species to transform the world to our specifications instead of adapting ourselves to the demands of the world, and that this ability is more or less fully intact by a child's second birthday.

But this ability to engage in shared intentionality does not emerge until after less sophisticated precursors. One does not need shared intentionality to make sense of the behavior of the museum-goer, the customer, and the golfer. Rather, one just needs to understand that their specific behaviors can reveal underlying mental states of goal objects—namely, that walking, pointing, and reaching reveal goal objects of a painting, a pack of cigarettes, and a golf club, respectively. The emergence of infants' understanding of others' behavior as goal-directed has been studied in developmental psychology for over a decade.

Research of Infants' Understanding of Goal-Directed Behavior

These studies began when Woodward (1998) demonstrated that infants as young as five months are able to detect an underlying intention or goal of an unfamiliar adult. Using the visual habituation paradigm, infants were shown the arm and hand of a person consistently and repeatedly reaching toward and grasping one of two objects on a stage; these were the habituation trials. On test trials, the toys' positions were switched on the stage, and, between participants, the adult's arm either took the same path to the other object or a different path to the same object. If the infant participants were to react to perceptual differences in the arm's reach between habituation and test trials, they would have dishabituated to the same toy, new path test condition. Instead, they dishabituated when the actor reached and grasped the different toy, even though the same path of reach was taken as during the habituation trials. This provides evidence that what was most important to the infants was not the perceptual details of the reach, but the underlying intent or goal state of the adult experimenter, which must be inferred (i.e., it was not where the arm was reaching that was important, but what the arm was reaching toward).

Woodward and colleagues have since greatly expanded the list of behaviors understood in infancy as goal-directed in others. The array now includes reaching without grasping (unfulfilled reach), pointing, eye gaze coupled with head gaze, and eye gaze coupled with emoting, which have all been revealed as understood to be goal-directed at or before 12 months (Hamlin, Hallinin, & Woodward, 2008; Woodward & Guajardo, 2002; Johnson, Ok, & Luo, 2007; Phillips, Wellman, & Spelke, 2002). Most notably, some research is beginning to move out of the visual habituation paradigm by assessing infant understanding via selective imitation, forced choice, or selective play (see Hamlin, Hallinin, & Woodward, 2008) The finding of these studies underscore the importance of understanding others' intentions as the basis for social cognition (Tomasello, 1999).

But these studies merely serve as static glimpses of understanding at distinct points across infancy. As Woodward (2009) notes, an account of the developmental processes that give rise to this knowledge is also necessary. Recent studies by Woodward, Sommerville, and colleagues have begun to unlock the mystery of developmental processes of goal-directed understanding in infancy, in what they call the self-experience hypothesis. This idea is that infants first achieve a level of competency in using a behavior as means to achieve a goal themselves. After this point, they are also able to understand that another person employing the same behavior may be trying to achieve a goal as well. First, in a mixed methods design, Sommerville and Woodward (2005a) demonstrated a covariation in infants' action production and action processing. Specifically, 10-month-olds who could planfully solve a means-end cloth-pulling problem also understood the cloth pulling behavior of another person as means to an end in the habituation paradigm. Meanwhile, age matched infants who could not personally solve the same problem did not distinguish between someone using new ends given the same means.

Whether infants' action perception was called upon to aid action production, or vice versa, was still left in question, however.

Following up this study, Sommerville, Hildebrand, and Crane (2008) again tested a 10-month-old sample in a study employing a different, more difficult means-end task—using a cane to retrieve a toy. In a between groups design, infants either received active training and experience using the cane to retrieve a toy, or merely watched another person demonstrate this behavior for the same amount of time. Next, in a habituation procedure, it was noted that only the active experience group of infants perceived cane use of another person as means to an end; the passive training group of infants did not make the means-end attribution. Finally, analogous findings were reported using an even younger sample of 3-month-olds (Sommerville, Woodward, & Needham, 2005). These participants took part in two separate procedures—an action procedure in which they gained experience using a velco mitten that facilitated the grasping of toys and a habituation procedure in which they watched an adult arm and hand reach for a toy while wearing a similar mitten. However, the order of these procedures was counterbalanced. Results indicated that the infants who had the action procedure first understood the actor's reach in habituation as goal-directed, while those who had the habituation procedure first did not make such an inference.

The work of Sommerville and Woodward has inspired research by others that specifically focused on the effects of infant self-produced locomotion. Cicchino and Rakison (2008) investigated the relationship between infants' crawling status and their understanding of self-produced motion in computer-generated stimuli. These infants watched two sets of objects on a screen during habituation trials. One set implied a launching event as the first object seemed to collide with the second, causing the first to stop and the second to start moving. The second set implied self-produced motion in the second object, as the first object moved onto the screen and stopped without touching the second, while the second object proceeded to move off screen anyway. Among the results found were that between groups of 7-month-olds who could and could not crawl, differential patterns in preferential looking were found between the launched and self-propelled objects during a test phase in which they appeared side by side on screen. The crawlers preferred to look at the object that did not move independently, while the non-crawlers tended to look at the object that started moving without an external force being applied to it. As age was held constant between the groups, we must conclude that the difference in preference looking between the participants was due to locomotive status alone. Important to note, however, is this study did not specify a causal relationship between action production and action perception.

These studies demonstrate the importance of action production as having a significant relationship with the development of action perception of another person. To the author of the present study, nothing in infancy demonstrates goal-directedness and personal agency like independent walking. Thus the topic for this senior thesis was established—to examine infants' perception of the walking of another person as a goal-oriented behavior. This research topic fills a gap in the literature in that a careful investigation of infants' understanding of walking as goal-directed has not yet been pursued.

The Behavior of Walking: Cognitive Aspects and Locomotive Precursors

The behavior of walking deserves an in depth look that past behaviors perceived as goal-oriented may not have warranted. While behaviors such as reaching, grasping, and looking can be done with minimal coordination within and among body systems, walking is a behavior that emerges much later in infancy and is the end result of much coordinated behavior, both mental and physical (Rab, 1994). Independent walking does not emerge in Western society without precursors in other forms of locomotion such as crawling, creeping, and cruising (i.e. supported walking). Consequently, independent walking involves much knowledge that is gained through these precursors.

Berenthal and Campos (1990) describe the early locomotive behavior of crawling as functionally organized, and in doing so they assert that requisite for its emergence are goal-directed propensities. This assertion likens locomotion as means to an end—in that locomotion is used in order to reach some other goal. This means-end nature of locomotion, combined with the necessary maturation of skeletal and muscular systems, may explain why crawling does not emerge until the second half of the first year of life.

Other mental abilities required for locomotion have also been identified. Berenthal and Bai (1989) noted that infants' sensitivity to optic flow follows a developmental progression that seems to correlate with their locomotive abilities. Their study employed a moving room apparatus; with the participant in the room, either the front wall, the side walls, or both could be moved toward the child, giving the illusion of self-motion. The stronger the participants perceived the optic flow as meaning they were moving forward, the more they would compensate by adjusting their posture in the opposite direction (i.e., leaning backward). The researchers found that responsiveness to optic flow peaks at nine months, at which point most infants are crawling or creeping but not yet walking.

Finally, with respect to agency, both parents and researchers agree that for an infant, independent walking is a different beast than any other motor milestone. Specifically, at least among early walkers, Biringen, Emde, Campos, and Appelbaum (1995) found a significant change in emotional communication between mother and child, including more "testing of wills" conflicts. What commonly underlies conflicts during a child's "terrible twos" is a simple clashing of intentions between two people. For example, the infant wants to push a lamp on the floor to see what will happen, and the parent does not want to spend time and money replacing said lamp. It seems that independent walkers are experts with regards to their own capabilities to act intentionally on the world. Consequently, they begin to discover that these intentions may conflict with those of their loved ones!

On the physical side, walking is a complex coordination of muscular and nervous systems during which infants must simultaneously generate movement while monitoring equilibrium to prevent falling (Rab, 1994; Berenthal & Campos, 1990). This coordination and multidimensionality makes walking a far more advanced behavior to produce than grasping, reaching, or pointing. This in part explains why a child's first steps mark a developmental milestone, while first reaches do not.

As described above, many of the requisite skills for independent walking are gained through previous locomotive behaviors. But can we conclude that all knowledge gained from these previous behaviors will transfer to upright walking? Work on locomotion by Adolph (1997) suggests no. In a longitudinal study, Adolph monitored infants' transitions from crawling to walking in relation to slope ascension and descent. As infants gained experience crawling, they were able to successfully traverse slopes of greater and greater magnitude. They also seemed to develop judgments of risk when examining slopes even before attempting to traverse them, such that infants would refuse to crawl down slopes judged unsafe. Later, as upright walkers, it was expected and found that infants could not successfully traverse steep slope grades that they could previously when crawling. The interesting finding, however, was that the knowledge of the safety of slopes did not transfer from crawling to walking. Infants would attempt to walk across slopes that they had previously deemed to risky to cross crawling! Infants needed to once again go through the same stages of judgment making for walking that they had already completed for crawling. This is evidence for the specificity of knowledge between forms of locomotion in infancy.

Overview of the Present Study: Incorporation of and Departures from Previous Research

In addition to the previous differences between the behavior of walking and previous behaviors found to be perceived in infancy as goal-directed, there is one more, rather conspicuous, set of differences. Walking is a gross motor behavior that can happen over great distances of space. Previous behaviors identified as goal-directed, namely reaching, grasping, pointing, and eye gaze, are either manual or fine motor behaviors that can take place in very near space. So while the investigators of the present study had every intention of having this experiment follow in the line of Woodward's seminal study (1998), certain adjustments and departures were all but necessary.

The investigators of the present study feel confident that enough procedural similarities between the current study and previous research with goal-directed behavior existed to make any and all results comparable. First and foremost, it was the experimenters' goal to have the infant participants encode behavior of another person demonstrating goal-directedness. In order for this to happen, participants watched a series of trials in which a walking behavior toward one of two stimuli was repeatedly modeled. By the end of these trials, it was assumed that participants had become familiarized with this behavior. The participant's understanding of this behavior was then put to the test during test trials. However, the three biggest differences between the present study and Woodward's work are the size of the presentation area at which the participants looked, the lack of infant-controlled habituation criteria, and a change in dependent variables. These differences shall now be explained further.

In Woodward's seminal study (1998), infants sat 30 inches away from the stage on which trials were presented, and the two key stimuli were displayed 10 inches apart from each other. To contrast, in the present study infants sat five feet, nine inches away from the pedestals in the display area, and the key stimuli were six feet, six inches away from each other. This enlargement was necessary to accommodate for the nature of walking, a behavior that takes place over a larger area than reaching or pointing does. This enlargement to accommodate walking has precedence in the literature. Berger (2004) adapted the A-not-B task so infants had to walk in order to reach the places of concealment instead of merely reaching while sitting. In doing so results that infants could both succeed and make the preservative A-not-B error were both obtained, much like in the original task. As such, the author of the present study believes that an enlargement of the procedural area will not compromise effects of the study.

Secondly, our study employed familiarization trials rather than habituation trials. The main reason for this was due to the impracticality to code infant eye gaze due to the large display area. Almost all of the participants' field of vision consisted of the display area. It seemed especially difficult to capture the entirety of infants' eye gazes that were directed toward the display with only one camera, no matter where the camera was positioned. The investigators chose instead to employ familiarization trials, much like those utilized by Cicchino and Rakison (2008), with which they were still able to attain significant results.

Finally, instead of using looking time as the only dependent variable, the author of the present study chose to have several dependent variables and focused on variables in which infants interacted with the stimuli. Again, this decision made more sense due to the infeasibility to track eye gaze over such a large display area. Moreover, the participants of the present study covered a wide age range warranting a variety of dependent measures that reflected their differing cognitive capacities. And, as mentioned previously, more interactive dependent measures have been employed in a past in study of goal directed behavior (Hamlin, Hallinin, & Woodward, 2008).

Dependent variables chosen for the present study include: looking time, exploring time, first toy touched, and toy shared. The time measures are specific to each of the key stimuli, with a higher time relative to one toy over another demonstrating a preference for it. The looking time was included as a rough analogue to the dependent variable in habituation experiments. It also catered to both the younger end of our sample, who may have been less inclined to manipulate the large stimuli, and the participants with a more inhibited temperament, who may have been perfectly content looking but less inclined to touch. Exploring time was defined as amount of time spent looking and touching one key stimulus simultaneously. As the walking experimenter was looking on as the infants played with the stimuli, it was expected that a social-referencing effect would take place, with the infants being more inclined to look at and explore the walker's target stimulus. Evidence for infants understanding social referencing was previously provided by Mumme, Fernald, and Herrera (1996), who demonstrated that infants tended to approach toys their caregivers emoted positively toward, while avoiding toys they emoted negatively toward. This exploring behavior, along with categorical data of first toy touched and first toy shared, were included as more overt behavioral dependent variables. Evidence that infants can be persuaded to share in infancy was taken by a study by Repacholi and Gopnik (1997), in which 18-month-olds inhibited their own egocentric desire for goldfish crackers in order to share broccoli with an adult who expressed an interest in the latter and an aversion to the former. All variables will be explained further at a later point.

A significant challenge researchers had to overcome was isolating walking from any other behavior that has been found previously to be perceived as goal-oriented in infancy. The participants could see most of the experimenter's body as he acted, including his head, arms, and hands. Care was taken so that infants did not use cues of grasping, reaching, pointing, eye gaze, head turn, or verbalization of the experimenter to infer his goal. This decoupling of confounds was accomplished in the following way. First, the experimenter turned his back to the participant before he walked toward the target stimuli. In this manner, the participant could not see or use the experimenter's eye gaze as a clue to his goal. Secondly, only whole body movements were taken toward the target stimulus, beginning with a large step. This means the experimenter's head did not independently turn toward the target, which would have allowed for the cue of head turn. The experimenter did not verbalize during his walk or after finishing it, nor did he reach or point to the target stimulus. Finally, at no point in the procedure did the participants see the experimenter touch either stimulus unless the participant shared one or both with him.

Finally, not all data collection could be obtained empirically without significantly extending the study session. The experimenters wished to obtain information regarding the participant's locomotive history and temperament. The former relates directly to a research question, while the latter could present a possible confound to the study. It is for this reason that we asked the parents of the participants to fill out two questionnaires while their children completed the study. These forms will be explained in greater detail later.

Study Hypotheses

As mentioned previously, the present study fills a gap in the literature by investigating a new behavior in the inquiry of goal-directed understanding in infancy—walking. It could be that infants do or do not appreciate walking as a goal-directed behavior. Moreover, in light of the previous research reviewed, various speculations can be offered as to at what point in infancy an appreciation of walking as goal-directed can be expected.

On the one hand one can turn to the work of Berenthal and Campos (1990) which suggests that infants are already adept at forming and acting on goals by the time they are crawling and only build on this understanding when they begin to walk. On the other hand the work of Adolph (1997) suggests that certain locomotive knowledge may fail to transfer during the transition from crawling to walking and must be built again. The work of Sommerville and Woodward (2005a) would propose the behavior of walking must be somewhat mastered by the infant before it can be understood as goal-oriented in another person, with crawlers unable to make such an inference. Finally, work of Cicchino and Rakison (2008) suggests that all forms of self-produced locomotion are indistinguishable when it comes to agency even in infancy, as they are all employed in order to traverse large areas of space. With this view, a crawling infant would interpret another's walking the same way as a walking infant would. The empirical question of the exact interaction of infant self-produced locomotion and subsequent understanding of walking as a goal-directed behavior underscores the importance of the present study.

In summation, the present study was designed to test whether locomotive experience would facilitate infants' encoding of the walking behavior of another person as goal-directed. In order to assess these selected independent variables, 24 participants were tested, with 12 of them independently walking by their test date, and the other 12 only crawling or walking with support.

As already noted, various predictions could be made as to whether one or both of these groups would perceive walking as goal-directed. It was the researchers' belief that the independent walking group would be very likely to infer goal-directedness from the walking behavior, and less likely but still possible for the non-walking group to exhibit this understanding.

Method

Participants

The sample consisted of 24 infants within the age range of 8 months 24 days to 16 months 19 days (*M* = 13 months 13 days; *SD* = 2 months 13 days). 11 were male and 13 were female. An additional 4 infants were tested but excluded from the final sample because of fussiness (1 infant) or failure to touch any stimuli (3 infants). The sample was further divided according to the selected independent variable of locomotive experience, with 12 independent walkers (*M* = 15 months 0 days; *SD* = 1 months 20 days) and 12 nonwalkers (*M* = 11 months 25 days; *SD* = 2 months 2 days). Participants were recruited via parental response to informational brochures distributed by the lab to residents of towns adjacent to the research university, and also specifically to the parents of children in the university's lab schools. Most participants were Caucasian, but the sample also reflected the ethnic diversity of the towns surrounding the research university.

Materials

The key stimuli for the present study, used during familiarization and test trials, were two custom-made toys. Each was comprised of a different set of commercially available construction toys, arranged and glued together in an interesting, novel way. The toys filled three dimensions of space and were approximately 6 x 6 x 6 inches. The larger size of the toys was necessary in order to be assured that the participants could readily perceive the toys in the display during familiarization trials, where they would be several feet away. However, despite their size, care was taken to ensure that the toys were still easily manipulable by the participants. The sides of the toys contained knobs and handles. The toys were also largely hollow in the middle, to ensure that they were not too heavy for the participants to play with. Finally, the toys' color schemes contrasted—one with cooler colors of blue and green, and one with warmer colors of orange and red. It was the experimenters' hope that the toys would be found as equally appealing yet clearly distinct entities by the participants. These toys can be seen in Figure 1.

Apart from the key stimuli, several additional toys were also used specifically for the warm up trials. These smaller toys were commercially available and were not construction toys. The set consisted of a frog, a fish, a dolphin, a banana, a barrel, and a spiky ball.

Some materials were present and used throughout the entire experiment. A Panasonic model camera was positioned to the infant's right on a windowsill and recorded the session. There also happened to be another camera to the infant's left that was inactive; its primary use was to record a different experiment that took place in the same room. But as these cameras were approximately equal distance from the infant's line of vision on either side, they counterbalanced any effects of having a camera present in relation to one side of the familiarization trial display.

The infant sat in an infant seat attached to a 24 inch by 42 inch table, with the top of the table 29.5 inches from the floor. From a distance 57 inches parallel to the front of the table, two pedestals, 78 inches apart, stood for displaying the key stimuli. They were identical and translucent gray in color and measured 42 inches high, and 12 inches in length and width. Two chairs also remained in a constant position throughout the experiment. The first was a chair for the participant's parent, approximately 48 to the right of and 24 inches behind the infant chair.

The second seated the second experimenter and was 30 inches directly behind the infant chair. Figures 2 and 3 illustrate the setup described.

Specifically for warm up and test trials, the main experimenter sat in a chair facing the participant within a few inches of the table's front. This chair was moved out of the participant's view when not in use. The experimenter used a 12 inch by 25.5 inch tray to impartially present sets of toys to the infant. This tray was white with side barriers to prevent the participant from pushing the toys sideways off the tray. Legs elevated its surface to two inches off the table's surface so it could easily be slid by the experimenter over the infant seat's bars. The tray was stored under the table out of the participant's view when not in use. Likewise, the stimuli and toys described previously were also stored under the table when not in use; they were placed in one wicker basket and another wicker basket covered the first to hide its contents.

For the familiarization trials, a cardboard tri-fold presentation display placed on the table acted as a screen to obscure the participant's view of the experimenter and pedestals. This ensured that the infant did not observe the experimenter handling the stimuli between trials. This screen measured 43.5 inches wide and 29 inches tall, and it was placed in between the pedestals or out of the participant's vision when not in use.

Finally, a packet of questionnaires was given to the parent to complete during the study. The first was a questionnaire of infant locomotive milestones, such as if and when the infant first started crawling and walking. This questionnaire was developed for the purposes of the present study and can be viewed in Appendix A. The second questionnaire was the 13-month-old version of the Infant Characteristics Questionnaire (IBQ), developed by John Bates (Bates, 1979; Pettit & Bates,1984). This questionnaire revealed information about the infant's temperament. Bates and colleagues have previously evaluated and reported the psychometric properties of the IBQ, revealing it to be internally consistent and reliable between test and retest. Primarily designed to assess levels of difficult temperament, the 13-month form measures four factors—infant fussiness, unadaptability, persistence, and unsociability—which have been demonstrated to be independent constructs as revealed by factor analysis. The locomotion questionnaire and the IBQ allowed for more information to be gained concerning the participant and allowed for parental attention to be less focused on the experiment.

Procedure

The participant and parent were greeted outside the psychology building and escorted to a waiting area. Before the experiment began, the parent was explained the details of the study, was allowed time to ask any questions, and signed consent forms. The participant and parent then entered the study room, with the parent sitting in the appropriate chair and the participant in the infant seat as described previously.

As a special circumstance, experimenters tolerated the participant to leave the child seat and instead sit on his or her parent's lap instead if he or she was showing signs of fussiness, irritability, or disinterest in the toys. In this case, the infant seat was removed from the table and taken away. The parent then moved his or her chair to the table. The infant in this circumstance still had approximately the same affordances for sight and action as before. Six participants were switched to their parent's lap for at least some portion of the procedure. While differences existed between infants' location in relation to the tabletop and view of the display area, they were extremely minor and ignored for the purposes of the study.

Warm up trials.

These trials were designed to get the participant used to interacting with the experimenter and with novel stimuli. Each trial started with the experimenter obtaining the participant's attention and presenting the participant with two toys, although not the key stimuli, on the tray. Once the tray was pushed toward the participant so that the toys on it were within his or her reach, 30 seconds of time was allotted for free play. At this point, if the participant had been willingly interacting with the toys, the experimenter made a request for the participant to share a toy. The experimenter said, “Could I have one?” while showing a positive facial expression and extending his hands to the participant in a cupped manner. This request mirrored the test trial requests to come later. For some participants the requests in this set of trials were modified to encourage sharing at the expense of objectivity; if the baby seemed hesitant in sharing, the experimenter would point specifically to one of the two toys and ask, “Could I have that one?”

Conversely, if the baby was so wary of the toys or experimenter to touch the toys, the sharing quest was often left out. Furthermore, if the participant was already on his or her parent’s lap at this point and still wary, the experimenter asked the parent to show interest in the toys and hand them to the participant. The goal of these trials was to have the participant consistently share with the first experimenter as quickly as possible, or at least to consistently and eagerly interact with the toys even when not willing to share. As such, the trials were designed with flexibility toward each participant. With the goal of having the infant share three times, a minimum of three trials and a maximum of six trials were possible.

Familiarization trials.

All participants experienced the same procedure during the familiarization phase. However, which key stimulus the experimenter repeatedly and consistently walked toward during this set of trials was counterbalanced between subjects. More specifically, one key stimulus was randomly chosen before the session to be the first experimenter’s goal. The experimenter walked toward this stimuli three times on each side of the display in a semi-random, counterbalanced order (i.e., ABBAAB).

The first trial in this series was unlike the rest. It was a preview trial that allowed the participant time to become accustomed to the display to be used for the next few minutes while not also having to interact with the experimenter. For this preview trial, the participant was able to see the two pedestals with one key stimuli resting on top of each. This preview trial lasted around ten seconds. The assistant then placed the screen back on the table.

The familiarization trials were supposed to be an approximation of those typical in the Woodward's goal-directed behavior paradigm, but "scaled up" for the walking behavior under investigation. The setup between these trials consisted of the assistant retrieving the screen and placing it on the table to block the participant's view of the display. The experimenter then prepared the display for the forthcoming trial, at which point the assistant removed the screen and took it with him or her out of the participant's vision.

At the beginning of each trial, the experimenter removed the screen from the table and stood facing the participant just behind the table's front, similar to where he sat for the warm up trials. The experimenter then attracted the baby's attention with a short line consisting of a greeting and his next actions (e.g. "Hi! I'm going to go walking now. Can you follow me? Here I go!"). The experimenter then turned his back to the baby in order to face the display. His turn was such that the first object he was able to see was the non-target (i.e., the object he would not be walking toward). The experimenter at this point made every effort to orient his head in the same direction as the rest of his body, in order to decouple the possible confounds of eye gaze and head turn. After briefly standing and looking directly between the two pedestals, the first experimenter took a large step toward one of the two pedestals, reorienting his entire body as a result, and took a series of approximately four more steps in order to reach the side of the pedestal. This walking was animated and included a spring in the experimenter's step, swinging arms, and audible steps. Total distance walked from in front of the table to the pedestal was five feet. The first experimenter then stopped next to the key stimulus and put his hands on his hips, as if to signal that he appreciated the target stimulus, but was not going to reach toward it. The experimenter paused at this position for about five seconds, with the entire time of each trial being about 15 seconds. The assistant's returning of the screen to the table top marked the end of a trial, at which point the experimenter switched the positions of the stimuli when called for. See Figures 4 and 5 for participant's eye views during familiarization trials.

Test trials.

Following the familiarization trials were a series of two test trials. Each of the two test trials contained two parts—one a social referencing measure, and the other a sharing measure. Again, the first experimenter was seated in front of the participant in a chair for these trials. First, the experimenter presented the two key stimuli on the tray, on the same sides as the participant originally saw them in the preview trial. Before the toys were within the participant's reach, the experimenter called the infant's attention (e.g., "Lookie here!) and allowed two seconds for the infant to look. The first experimenter then pushed the tray all the way toward the infant, maintaining a neutral facial expression and not looking at either toy. The participant was free to play with the stimuli for up to one minute.

At the end of this time, if both toys were on the tray and not being grasped by the participant, the experimenter pulled the tray with both stimuli away, reset the position of the toys, and began the second component of the test trial. If the participant was lifting or actively grasping either or both toys, however, the assistant removed these toys from the participant's hands and returned them under the table to the experimenter. This was to ensure that the participant did not see the experimenter touch either of the key stimuli. See Figure 6 for a photo of a stimulus being passed.

The second part of the test trial consisted of the experimenter resetting the stimuli to where they were and presenting them again for the participant. Again, before the stimuli were within the participant's grasp, the first experimenter again obtained the infant's attention, but this time also made a request to share (e.g., "Hi! Lookie here! Can I have one?"). The experimenter then placed one cupped hand in between the two stimuli while he used the other hand to push the tray toward the participant. When the tray was pushed in, the experimenter then added the pushing hand to the other cupped hand. The experimenter now showed a more positive facial expression, but did not favor either stimulus. The baby was allowed 30 seconds to share a toy. Every 10 seconds, the first experimenter was allowed to repeated the request, but only if the participant was not favoring either stimuli. This was to prevent any bias in interpretation of the request toward one toy over the other.

The same procedure was again used to retrieve the stimuli after the trial. The test trial was then repeated once more; again, the first component was a social referencing period followed by a toy reset and a sharing request. The second test trial differed from the first only in that the experimenter counterbalanced the stimuli for position on the presentation tray. The stimuli were located on the opposite side of the participant as they saw them in the preview trial.

Scoring

Infants' behavior during test trials was coded from videotape. The procedure for scoring was such that two people collaborated to code any one participant's data. One person was responsible for the manipulation of the camera and the counting aloud of seconds as they passed, while the other individual noted behavior on a television screen and recorded it on the study's scoring sheet, which can be seen in Appendix B. As such, only one person was actually scoring, with the other greatly facilitating the scoring process by handling the logistical aspects.

As described earlier, each test trial was broken down into two components—social referencing and sharing. Different behaviors were coded during these different components.

During social-referencing trials, a maximum of 20 seconds of looking and 20 seconds of examining behavior were coded, with the trial beginning either when the tray holding the stimuli was pushed fully toward the infant, or when the infant intentionally touched a stimulus, whichever came first. Looking behavior was defined as the infant having a stimulus within their line of vision during any scoring second. Examining behavior was defined as the infant both having the stimulus within their line of vision and touching the object with at least one hand at the same time. Key to scoring in these trials is that infants were allowed their 20 seconds of looking time to either completely overlap or be completely separate from their 20 seconds of examining time. In other words, the researchers wanted to ensure that an infant who looked for a number of seconds before examining would not be penalized in having less examining time to score. So, while looking time coding always began at the beginning of the trial, the beginning of examining behavior coding was deferred until the participant exhibited such behavior, or until his or her 20 seconds of looking time had expired, whichever came first. For each second, a note was made for which, if either, stimulus was looked at or examined. Finally, the requirement of two social referencing trials per infant was set, and during both trials both looking and examining behavior were required to take place. Two infants in our final sample did not meet this criteria during their two designated social referencing trials—one because the infant failed to examine either stimulus and another because the infant became fussy between the first and second test trials. For only these two infants, the first sharing trial was substituted for their second social-referencing trial.

A much simpler coding scheme took place during the sharing trials. A categorical behavior of which, if either, toy the baby shared first was noted during sharing trials. Sharing was defined as picking up a stimulus and placing it in the palm of the experimenter's cupped hands. If the baby shared both toys, which rarely occurred, only the first toy shared was counted; the investigators assumed that this toy was that which the participant wished to share more.

Reliability scoring was performed on four participants, or one-sixth of the sample. This reliability coding yielded 16 independent scores for social-referencing trials (with two trials per infant and two stimuli to interact with). Of these 16 scores for examining time, the maximum discrepancy in total time between the reliability coder and the primary coder was three seconds, with an average discrepancy of only .88 seconds. Agreement for the variable of looking time, an ostensibly harder behavior to code, was even more reliable. Of the 16 scores, none differed between the primary scorer and the reliability scorer by more than two seconds, with an average discrepancy of only .75 seconds.

Finally, there were 8 independent scores for the categorical variable of toy shared during sharing trials. The coders agreed on whether or not sharing took place for all eight trials, a 100% agreement rate. Furthermore, in the trials in which they both agreed that sharing took place, they agreed five out of five times on which toy was shared, for a 100% agreement rate. As the average error for continuous data trials was less than one second, and agreement percentage for categorical data was above 90 percent, it was concluded that the scoring system was reliable enough for tests of inferential statistics.

Results

For all data analyses, experimenters decided to only use data from the first set of test trials (i.e., one social-referencing trial and one sharing trial). Despite the inclusion of a second set of test trials in order to collect more data and to counterbalance for toy position on the presentation tray, it was suspected that the participants' behavior in the second test trial was based less on information learned during familiarization trials, and more based on information learned during the first set of test trials. The exclusion of the second set of test trials was meant to exclude the influence of perseveration and to best capture participant data that reflected their understanding of the experimenter's walking.

Temperament

First, a qualitative examination of the final sample demonstrates a variety of temperaments. Scores to the Bates 13-month-old Infant Behavior Questionnaire were recorded and tallied for 22 of the 24 participants in the final sample. The four factors identified by the Bates IBQ were fussiness, unadaptibility, persistence, and unsociability (Pettit & Bates, 1984). Among the sample, there was at least one participant who was rated by their caregiver to be outside of one standard deviation in either direction from the mean for all four categories. This means that the sample included infants whose difficult temperament did not prevent them from completing the procedure in addition to babies with easy temperaments more conducive to experimental demands. Specifically, the sample included one fussy baby, five unadaptable babies, three persistent babies, and two unsociable babies, or eight infants in total that fell above one standard deviation for at least one of these categories who nevertheless completed the procedure. It would be fair to conclude that the procedure was adaptable for infants of all temperaments.

Preliminary Analyses

Next, a number of inferential tests were performed in order to see if any confounds or unexpected mitigating factors demonstrated a systematic influence on the participants or data.

Gender.

Tests were conducted in order to determine whether participant gender was predictive of more interaction with stimuli or behavior consistent with the research hypothesis. This gender effect could be due to genetic or environmental factors based on the participants' sex, or could have reflected the fact that the experimenter for all participants was male. First, an independent samples t-test was performed to determine whether one gender explored the stimuli more than the other. It was found that males (M = 13.3636 seconds) did not differ from females (M = 11 seconds) on average examination time during the first test trial, $t(22) = 1.51$, $p = .15$. Furthermore, another independent samples t-test demonstrated that males (M = 46.36%) were no more likely than females (M = 47.46%) to confirm the research hypothesis of the study by examining the target stimulus more, $t(22) = 0.12$, $p = .91$. The gender of the participant, therefore, did not predict greater involvement or greater understanding of walking as goal-directed.

Target stimulus.

Next, tests were conducted in order to determine whether participants as a group preferred one stimulus over another, regardless of whether or not it was the target stimulus. As the blue toy was the target stimulus for 13 participants and the orange toy was the target stimulus for 11 participants, it was expected that across participants percentages of examination time should be around 50% for the blue stimulus.

A one-sample t-test demonstrated that the entire sample (M = 62%) spent significantly more time examining the blue toy than the expected sample mean of 50%, $t(23) = 3.11$, $p < .01$.

However, this bias toward the blue toy did not exist amongst both walkers and non-walkers. A one-sample t-test demonstrated that non-walkers did overwhelmingly favor the blue toy (M = 70.58%) over the expected sample mean of 50%, $t(11) = 3.95$, $p < .005$. However, the walking group did not examine the blue toy (M = 53.42%) more than the expected mean of 50% $t(11) = 0.73$, $p = .48$. This systematic bias based on toy color presents an unexpected confound and will be elaborated on in the discussion section.

Planned Tests of Inferential Statistics

Originally, sharing was chosen as a dependent variable. What the experimenters did not anticipate, however, was the general inability and/or disinterest in the non-walking group to share. Of the final sample, 25% of the non-walkers shared and 75% did not, while for walkers, 75% shared and 25% did not. A chi-square test of association demonstrated that non-walkers were significantly less likely to share than walkers $\chi^2(1, N = 24) = 4.17$, $p < .05$. It did not seem meaningful to conduct tests of inferential statistics with such a low sharing percentage for non-walkers.

First, categorical data were created based on which stimulus participants explored more during their social referencing trial. If a participant spent equal amounts of time with both stimuli, it was counted against the research hypothesis. Overall, 9 of 24 participants examined the target stimulus more than the non-target stimulus, a level not significantly different from chance ($z = -1.02$, $p = .31$). Furthermore, a Fischer exact probability test revealed no significant difference between walkers and non-walkers on this measure ($p = .99$). Table 1 provides cell and marginal totals for this measure.

Similarly, categorical data were created based on which stimulus participants looked at more during their social referencing trial. Among the entire sample, 11 of the 24 participants looked at the target stimulus more than the non-target stimulus. A binomial revealed that this level did not differ significantly from chance (z = -0.2, p = .83). Furthermore, a chi-square test of association revealed that walkers and non-walkers did not significantly differ on this measure $\chi^2(1, N = 24) = .67, p = .41$). Table 2 provides cell and marginal totals for this measure.

Next to be examined was whether participants chose to explore the target stimulus first during their social referencing trial. Fourteen of the 24 participants explored the target stimulus first. A binomial demonstrated that this was not a significant preference toward the target stimulus (z = .61, p = .54). Furthermore, a chi-square test of association determined that walkers were no more likely than non-walkers to examine the target stimulus first $\chi^2(1, N = 24) = .17, p = .68$). Table 3 provides cell and marginal totals for this measure.

As none of the categorical data yielded results in favor of the research hypothesis, next continuous data were analyzed. First, percentage of exploration time to the two stimuli were examined. A one sample t-test demonstrated that the sample as a whole did not spend more time examining the target stimulus (M = 46.96%) than was expected by the chance level of 50%, $t(23) = -0.67$, p = .51). Furthermore, an independent samples t-test demonstrated that walkers (M = 47.08%) were no more likely than non-walkers (M = 46.83%) to examine the target stimulus more, $t(22) = 0.03$, p = .97).

Finally, continuous data of looking time were analyzed. A one-sample t-test revealed that the sample as a whole did not spend more time looking at the target stimulus (M = 46.38%) than would be expected by the chance level of 50%, $t(23) = -0.88$, p = .39). Additionally, an independent samples t-test revealed that walkers did not spend a significantly greater amount of time (M = 47.58%) looking at the target stimulus than did non-walkers (M = 45.17%), $t(22) = 0.29$, p = .77). In conclusion, planned inferential analyses yielded no support for the research hypotheses of the study, that either the sample as a whole or only the walkers could perceive the experimenter's walking as goal-directed.

Post-Hoc Tests

As neither walkers nor non-walkers demonstrated understanding of walking as goal-directed as a whole, the researchers decided to further subdivide the walker group in order to see if some portion of it exhibited more evidence of understanding. These groups consisted of the half of the walker group that was oldest and the half that had the most experience walking. The measure chosen for analyses was first stimulus explored during the social referencing trial, as this was the measure that was closest to approaching significance among the entire sample.

First, of the oldest six walkers, four chose to explore the target stimulus first and two did not. A binomial determined this result as not significantly different from chance ($p = .69$). Among the six most experienced walkers (with at least eight weeks of independent walking experience), five explored the target stimulus and one did not, however a binomial revealed that this result did not differ significantly from chance ($p = .22$). Hypothetically, given a sample size twice that of the present study and the same percentage of hypothesis confirmation, the binomial would have been statistically significant ($z = 2.02$, $p < .05$). This provides some weak evidence for the self-experience hypothesis, which will be examined further in the discussion section.

Discussion

The investigators of the present study were confident that the walking participant sub-group would be able to infer the walking behavior of the experimenter as goal-directed and thought that non-walkers could plausibly do the same. However, the statistical analysis conducted suggests that no portion of the sample perceived the walking behavior of the experimenter as goal-directed. While there many have been only one way to interpret results consistent with our research hypothesis, the null findings of the present study can be interpreted in a multitude of ways. These results are especially troubling when taken in light of previous research demonstrating a number of other behaviors infants seem to understand as goal-directed at an age younger than the range represented in the present study. In fact, no researcher cited in the literature review would have expected null findings for both walkers and non-walkers. This discussion will mainly focus on the shortcomings and limitations of the present study, moving from more procedural and logistical issues to more theoretical issues.

First, the most reasonable question to be asked of any study with null findings is whether the experimental manipulation was successful. In the present study, it was fully necessary for the participants to attend to the experimenter as he walked and stopped beside the target stimulus throughout the familiarization trials. Otherwise they would have had no evidence on which to base the experimenters', and subsequently their own, preference. Scoring did reveal our manipulation to be successful. It was determined that for the 24 participants in the final sample, each looked at the experimenter at some point between when he started walking to when he was positioned beside the target stimulus during every familiarization trial. This finding yields the conclusion that there must be other reasons for the null findings of the present study.

However, the effectiveness of our experimental manipulation may have created an unintended confound of attention given to the two stimuli during the familiarization trials, resulting in a novelty preference for the non-target stimulus during test trials. Numerous studies using the habituation paradigm rely on infants' novelty preference come test trials. Our study departed from the visual habituation paradigm in that we had the infants interact with the stimuli instead of measuring any change in looking time between familiarization and test trials. But since the participants were very successful in tracking the experimenter to the target stimulus, some may have missed out on opportunities to look at and encode information about the non-target stimulus. In turn, when it came time for test trials, some participants' behavior may have reflected their lack of experience viewing the non-target stimulus instead of the experimenter's expressed preference toward the target. The combination of some participants' behavior reflecting knowledge of the walker's goal and other participants' behavior reflecting a novelty preference for the non-target stimulus may have yielded the null results. The purpose of the preview trial was to allow time for equal encoding, but as no criteria were established for looking at either or both toys during this trial, it cannot be concluded that the trial was effective.

This differential attention effect is only exacerbated by the present study's use of a large display area. While heartened by the effectiveness of Berger's (2004) enlarged A-not-B task, in retrospect, that study did not need to worry about equal encoding during familiarization, while the present study did. As our display pedestals were 42 inches apart, it was virtually impossible for participants to attend to both stimuli at the same time or to quickly and effortlessly switch attention between them. This was not a problem in Woodward's (1998) seminal study, in which the stimuli were only 10 inches apart. More precautionary steps should be taken in any future studies to ensure that any stimuli for participant discrimination be equally encodable.

Next, as was mentioned in the method section, care was taken to ensure that any enticing feature that one stimulus had was "evened out" by the other toy. For example, the blue toy was slightly larger, but the orange toy was a warmer color. Despite this care, a large, unexpected finding that compromised much data was the non-walking group's overwhelming preference for the blue stimulus, regardless of whether or not it was the target stimulus. In this case, even if the participants did understand that the walker had a goal object, this understanding was not enough to inhibit their own initial preference. While we cannot articulate what aspects about the blue toy made it more engaging, or why this preference was only expressed by the non-walkers, it reveals that in the future experimenters could let pilot testing decide what toys are equally appealing instead of relying on intuition. This one problem made results from the non-walking group all but meaningless.

Furthermore, the experimenter of the present study may have made another mistake in selecting stimuli. In pursuing toys that would be equally appealing, he custom-made novel toys that infants were guaranteed never to have seen before. Although only realized upon retrospection, this is a stark departure from previous stimuli used in goal-directed behavior studies. These stimuli have included stuffed toys, balls, and plastic figures of boats and dinosaurs (Phillips, Wellman, & Spelke, 2002; Woodward, 1998; Hamlin, Hallinin, & Woodward, 2008). These toys would all seem to be more familiar to infants, with the result that less time would be necessary for infants to encode information about the toys themselves before they would start encoding information about the experimenter's behavior toward them. If, for example, infants needed four trials to encode information about the target stimulus, then they only had two trials to encode the experimenter's preference toward it. Finally, the experimenter's choice of novel toys could have exacerbated the selective attention confound explained already. The conclusion to be drawn here is that when looking for toys that participants will have equal levels of experience with, it is not necessary to start from scratch; two mundane toys may have led to more successful results.

Next, upon reflection the researchers of the present study have found a flaw in the presentation of walking behavior. While the participants could see the experimenter moving toward the pedestals during familiarization trials, they could not see his feet touching and leaving the ground, which quintessentially defines walking from other locomotive behaviors. As explained previously, walking is a complex behavior that requires coordination within and between body systems from brain to toe (Rab, 1994; Berenthal & Campos, 1990). As such, it could even be called into question whether the participants perceived the experimenter's behavior as walking or not. Surely, in previous work, there was no question whatsoever as to whether the participants saw all the defining characteristics of other goal-directed behaviors, such as a reaching, grasping, and pointing (Woodward, 1998; Hamlin, Hallinin, & Woodward, 2008). While one could have viewed the experimenter's locomotive behavior and ruled out other forms of locomotion by process of elimination, we cannot trust that infants made this inferential step. In future studies, the behaviors that define walking should be visible to participants who are supposed to identify it; if participants were sitting on the floor, for example, they could easily see the entirety of the walking experimenter's body.

Next to be addressed are possible problems resulting from the dependent measures selected in the present study. The overwhelming paradigm used in previous goal-directed behavior has been visual habituation, with the primary dependent measure being looking time during test trials. The researchers of the present study chose to depart from this measure, given lack of feasibility and under evidence of a few studies that employ more explicit behavioral measures (Hamlin, Hallinin, & Woodward, 2008; Mumme, Fernald, & Herrera, 1996; Repacholi & Gopnik, 1997). However, in doing so they may have undermined the ability to find significant results for several reasons.

First, there is evidence indicating that infants are capable of demonstrating their understanding through implicit measures before they exhibit understanding explicitly. As a case in point, Ahmed and Ruffman (1998) tested 10-month-old infants on two versions of the A-not-B error task: a manual search task, and a habituation non-search task. It was found that the participants' looking time data in the non-search task suggested that as a group they remembered the correct location of a toy in a hidden location after a delay of 15 seconds, while not a single participant could manually search for a hidden object at the correct location after a delay of 15 seconds. This study is evidence for a demonstrable difference in understanding as revealed by implicit measures such as looking time in a habituation paradigm and explicit measures via goal-directed behavior or language. A plausible explanation for this difference is that in explicit measures, but not implicit measures, memory and action must be integrated. In return to the present study, it could be that it is especially difficult to understand walking as goal-directed in comparison to previous behaviors identified as understood as goal-directed in infancy. If this is the case, it could be that the participants in this study did have had an understanding that was still only in an implicit form. So while we found null effects for our explicit measures in a sample ranging from 10-17 months, an employment of the visual habituation paradigm could have revealed a significant understanding in either just the walking group or in both groups.

Conversely, one could make an argument that, once it was decided to use explicit behaviors as dependent measures, the wrong behaviors were chosen. There existed a disconnect between the explicit behavior demonstrated by the experimenter (walking) and the behaviors available for participant use with the stimuli (exploring and sharing). This contrasts with the other study of infant's understanding of goal-directed behavior, in which reaches and grasps were demonstrated and then participants were left to reach and grasp themselves (Hamlin, Hallinin, & Woodward, 2008). This similarity of independent and dependent variables also harkens back to a study by Meltzoff (1995) in which 18-month-old participants saw an adult attempt and fail behaviors with stimuli then were given a chance to use the stimuli themselves. Instead of similarly failing, they chose to complete the unfulfilled goals of the adult. It is not perfectly clear to what extent aspects of imitation or mimicry of the demonstrated behavior are necessary for infant participants given the use of explicit dependent variables. What is clear is that, in the present study, there was little to no surface similarities between dependent behaviors such as exploring and sharing and the independent measure of walking. In a follow up study, it would be interesting to have participants walk or crawl to the stimuli during a test phase. In this new measure, no inference would need to be made that different goal-directed behaviors are understood, encoded, and enacted similarly.

More generally, the investigators seemed to misinterpret the meaning of social referencing as used in previous research (Mumme, Fernald, & Herrera, 1996). It was assumed that infants who understood the experimenter's walking as goal-directed would direct their goal-directed behavior toward the same stimulus when the experimenter was present. However, in the procedure employed by Mumme and colleagues, infant participants were not inferring goal states in the experimental confederate (who happened to be their caretaker). Instead, they merely picked up on emotional cues and used these cues to shape their own behavior. Social referencing seems to relate best to the communication of emotional states, not goal states. In other words, the participants could have understood the walker's goal, but if this goal did not mirror their own preference, social referencing alone would not have compelled them to change their goal.

Next, a critique received during the carrying out of the present experiment was the lack of realism in the experimenter's behavior during familiarization trials. Namely, if the experimenter truly wanted the toy he was walking toward, his behavior would not have ended with walking, but would have continued with a reach and grasp of the toy! Of course, adding a reach and grasp would have clarified the goal of the experimenter, but it also would have confounded any results about goal-directed walking independent of other behaviors already established as goal-directed.

While the experimenter tried to make his walking quite oriented toward the target stimulus with bouncy steps, swinging arms, and loud stepping sounds, ultimately this walking did not bear apprehension of the toy. If participants' thoughts resembled the following: "Hmm, he seemed to want the toy, but isn't grabbing it; maybe he's changed his mind and no longer wants the toy," then perhaps the researchers have grossly *under*estimated their understanding! It could be concluded from our participants' "null" dependent findings that walking in isolation is *intentionally* not perceived as goal-oriented, at least in infancy, without additional mitigating factors. These factors could be as simple as accompanying reach and grasp, or could be more complicated, such as rational reasons for the unfulfilled goal. For example, in a very recent study, Luo (2010) demonstrated that 8-month-olds consider situational constraints when considering whether or not eye gaze is a goal-directed behavior. Between subjects, the experimenter in this study looked toward a nearby toy, but did not reach to grasp it either because her hands were occupied holding the handles of a sippy cup or for not ostensible reason whatsoever. Participants only treated the experimenter's eye gaze as goal-directed in the hands occupied condition. The goal completion in the present study also failed to happen, but there were no circumstances preventing the experimenter from apprehending the target stimulus. Another interesting empirical question for a follow up study would be infants' response to an experimenter's walking behavior toward a toy while his arms are occupied in some manner.

However, there is a more parsimonious explanation for the null findings of the present study than intentional perception of the behavior presented as not goal-directed. This explanation concerns one last difference between the behavior of walking and the previous behaviors identified as perceived as goal-directed in infancy not accounted for in the literature review. While behaviors such as reaching, grasping, pointing, and eye gaze seem to focus one's attention toward a particular object, in the behavior of walking one is focusing his or her attention on reaching a specific location. This is to say, infants may appreciate the goal-directed nature of walking, but the researchers of the present study failed to realize that the goal of walking is different than the goal of reaching, grasping, pointing, and eye gaze! In layman's terms, these prior behaviors focus on "what," or an object in relation to the actor, while walking focuses on a "where," or a location in relation to the actor. So where did the experimenter in the present study walk to during familiarization trials? He walked off to the left side of the room three times and off to the right side of the room three times. If the most important goal of walking is reaching a particular location, what evidence of a clear goal would this behavior provide? None!

In a unison of the previous two points, we may also need to conclude that walking has two possible goals—it can either be object-directed or location-directed. Even as the author of this study wrote in his literature review that locomotion can be likened to the means in an means-end behavioral sequence, he failed to see the importance of this statement to the study. Walking can be a means to an end in itself if the person walking only wishes to transport him or herself to a new location. However, the majority of the time when someone walks it the first step of in completing a goal that cannot be met until he or she arrives at a new location. In other words, the motivation for locomotion could be the act of walking itself (end in itself), reaching a certain destination (still an end in itself), or a first step in reaching a destination at which one is motivated to perform an additional behavior (means to an end). For example, how did Adolph (1997) get children to traverse her sloped walkway that could potentially be risky? She had the participants' caregiver stand at the far end! A debate between whether reaching one's mother is an intrinsic reward and an end in itself or a first step in receiving additional care is a moot point, but infants also frequently initiate locomotion in order to obtain and play with a toy. The only way one can tell whether the locomotion of another person was an end in itself or a means to an end is to view what that person does once he or she arrives at the destination. In the present study, since the experimenter did nothing after reaching his destination, it can be concluded there was no secondary goal to his walking and his goal was only to reach a new destination. Thus, during the familiarization trials some information was given in support of the encoding of walking as an object-based goal and a location-based goal.

Of course, one could easily design a follow up experiment to distinguish between the perception of walking as object-directed or location-directed. For example, imagine the present experiment recast as a strict visual habituation experiment, almost exactly like the seminal Woodward study (1998). During habituation trials, the walker would consistently walk to one stimulus on one side of the display. Come test trials, the toys would be switched, and the walker would either take the same path to the new toy, or a new path to the same toy. If infants dishabituated to the old path, new target toy condition, this would imply that walking is perceived as object-oriented in infancy. However, and in contrast to Woodward's findings, infants could dishabituate to the new path, same toy condition, demonstrating in the process that walking is better understood as location-directed in infancy.

This encoding of locations by our participants opens up an unexpected can of worms: the role of spatial cognition in infancy as it relates to the present study. If the participants were encoding the walking behavior witnessed as a path to a point in space, what did their resulting mental representation consist of? To quickly dabble in this area of research, insightful work has been done by Acredolo and Evans (1980) and Bushnell, McKenzie, Lawrence, and Connell (1995). This work has revealed on a number of encoding strategies infants use, and when these strategies are replaced by more sophisticated ones. First, infants around six months of age encode spatial relations egocentrically, or in relation to their own location. Next, at around nine months infants are able to use a direct landmark to remember the location of a stimulus (Acredolo & Evans, 1980). Finally, emerging around 11 months, but not consistently effective even by 12 months, infants attempt to use an indirect landmark to refer to the location of a stimulus; this strategy proves less effective than egocentric encoding (Acredolo & Evans, 1980; Bushnell et al., 1995). These latter two strategies can be called objective, or geocentric encoding, as the infant's own location does not matter in his or her representation. In the present study, infants could have used egocentric or several varieties of geocentric encoding strategies to determine the walker's final location. Unfortunately, very few of these strategies would be useful for the purposes of selective behavior toward one of two stimuli come test trials.

In the case of egocentric coding, as alluded to previously, the infant would have encoded three instances of, "walker is going to my left," and three instances of, "the walker is going to my right." Neither side would win, resulting in no clear location-based goal being established. Next, participants may have encoded using the geocentric goal of a direct landmark. This landmark would be a discernable feature of the room that happened to be on the same side of the room as the walker's end location. In the study, the door to the room was on the participants' left, and a window was to the participant's right. Even if participants used this non-egocentric landmark system, they would have resulted in having encoded three instances of, "He is walking near the door," and three instances of, "He is walking near the window," resulting again in no clear goal. The only way infants could have created an impression that the walker's behavior was associated with the target stimulus would be to encode his movement with relation to the target stimulus as an indirect landmark that was capable of moving. In this instance, the infant would have encoded six instances of, "the walker has walked in the vicinity of the blue toy," no matter whether it appeared on the left or right side of the room. Then, come test trials, the infant would have had to assume that the area near the blue toy was still the walker's goal in this new, third location, and also assume that the orange toy was too far away from the blue toy to have been in the area of the walker's goal. This seems like a difficult task, indeed.

With all of the above shortcomings, it is at this point that the author feels less disheartened that the present study did not yield any significant results on the planned analyses. However, a certain set of post hoc analyses is still be open for interpretation—the behavior of the most experienced walkers. The six participants tested with eight or more weeks of independent walking experience tended to explore the target stimuli first on the first social-referencing test trial, although this effect was not significant. Various speculation can be offered as to the reason for this effect, which may have been significant with a larger number of experienced walker participants.

It is key to remember that this result of first toy explored was less robust for those participants who happened to be the oldest, regardless of walking experience. This is support for the hypothesis that action production aids in action perception independent of other levels of cognitive development (Woodward, 2009). Taken from the perspective of work conducted by Sommerville and Woodward, this would mean that despite all the shortcomings of the present study, experienced walkers were still able to identify the walker's goal as object-directed, and remembered this goal until the beginning of the first test trial. This understanding was enabled by the ample experience these participants had walking toward objects they desired, which had become available for generalization to the behavior of others.

Conversely, follow up work by Acredolo (1990) suggests that self-produced locomotion can also lead to more sophisticated methods of spatial encoding, which could also account for this near-finding. In her interpretation, before self-produced locomotion, an egocentric method of encoding space is not only simple, but is also quite effective for the infant employing it. This is because the places pre-locomotor infants find themselves are the places their caregivers put them, such as a crib, a high chair, or a playpen. These infants only see the rooms these objects are located in from one vantage point, so a geocentric point of view is not necessary. It is only at the advent of crawling and other forms of locomotion that infants are consistently presented with counterevidence that an egocentric encoding method could not account for. What was once to one's left can now be to one's right after a change in position. Acredolo attributes the adoption of more sophisticated spatial encoding methods to the onset of self-produced locomotion. In the present study, the infants with the most walking experience have had the most data to work with in order to come up with a method of encoding that could confirm the research hypotheses of the present study. If the experienced walkers were using an indirect landmark encoding strategy, it is possible that they were able to infer that the walker's goal was associated with the target object, even if this goal was location-based and not object-based.

Of course, seeing as the results of the most experienced walkers were non-significant, they are just as likely to be spurious as they are to be indicative of a finding consistent with the research hypothesis. Due to the unsettled nature of the present study, as well as competing hypotheses for the speculative findings, further research is warranted. The conclusion will deal with the author's best stab at future directions that would settle the many issues raised by the results of this study.

As best as the author can see, a series of three experiments is necessary to tease apart the myriad of issues presented by the present study. This conclusion was drawn based on the author's intuitive hunch that the goal of walking can either be encoded as a location (i.e., an end in itself), or as an object (i.e., as means to an end). A previous study that warrants this assumption was conducted by Carptenter, Call, and Tomasello (2005). It was demonstrated that 12-month-olds could flexibly encode the play behavior of an adult as either an end in itself or means to an end. Specifically, the infants viewed an adult use his hand to move a plush mouse from one location to another while making novel sound effects and hopping motions. The terminus location was either a nondescript point on the experimentation table (no house condition) or a toy house (house condition). After this demonstration, participants were given a turn to play with the toy mouse. In the no house condition, infants imitated the novel sound effects and hopping motion of the adult, while in the house condition the participants merely placed the mouse on the house without any sound effects or hopping motions. This study highlights infants' sensitivity to the ultimate goal of another's behavior, and the resulting differences in encoding and reproduction of behavior. It is based on results such as these that the author believes infants plausibly have the capacity to encode walking as an end in itself or as means to an end, depending on the context. These three experiments, in which the largest change from the present study will be a switch to looking time as the only dependent variable, will now be elaborated upon.

The first experiment will address the questions, "Are infants capable of encoding the goal of another's walking as an end in itself?" This experiment will be "bent" toward an interpretation of walking as motivated toward reaching a location, not reaching an object. The basic layout of the display area would be much similar to that used in the present experiment, with a few alterations. First, setup would include two doorways that would act as possible location-based goals. These doorways would be identical in size but differently colored. This would allow for a landmark-based encoding scheme in addition to an egocentric scheme. Beyond these doorways would be pedestals with objects on them, just as those used in the present study. During familiarization trials, the experimenter would consistently walk to one doorway, then stop upon reaching it with his arms on his hips, in the same manner as in the present study. Come test trials, the stimuli on the pedestals would be switched, and the experimenter would alternate on four test trials between taking the same path to the same doorway but different stimulus and taking a new path to a new doorway and same stimulus. Looking time would be measured during these test trials, and infants' novelty response would reveal which test trial condition seemed more unexpected. If infants are capable of perceiving the actor's goal as location-based, they should reliably look longer on the new path, same toy test trials than the old path, new toy test trials.

Next, the second experiment would address the question, "Are infants capable of encoding the goal of another's walking as means to an end?" To contrast with the first proposed experiment, this experiment would be "bent" toward an interpretation of walking as motivated toward reaching an object, not reaching a location. This experiment would not utilize the doorways mentioned previously but would still use the stimuli placed on pedestals. On familiarization trials, a procedure nearly identical to that used in the present study would take place. Participants would watch the experimenter walk toward the same toy that would be counterbalanced for side between trials. However, the walker will be unable to reach and grasp for the stimuli because his arms are occupied holding a wrapped blanket around him. Come test trials, the stimuli would remain in the same location, and the actor would alternate between taking paths to the same toy he had been walking toward during familiarization, and taking paths toward the toy he had not walked toward. Again, looking time would be measured during these test trials, and infants' novelty response would reveal which test trial condition seemed more unexpected. If infants are capable of perceiving the actor's goal as object-based, they should reliably look longer when the actor approaches the novel stimulus than when he approaches the target stimulus.

The final experiment would combine aspects of the previous two experiments in order to present the goal of the actor's walking as ambiguous, i.e., easily be perceivable as location-based or object-based. Doing so would pit the explanations of Sommerville/Woodward and Acredolo against one another, by asking, "Do infants tend to interpret the behavior of walking as means to an end, or as an end in itself?" Cues for perception of the walker's behavior as an end in itself and as means to an end would both be present, as was the case in the present study. However, no cues will be present as evidence against perception as object- or location-based. The doorways would be involved in this experiment, serving as a plausible location-based goal. In addition, the walker will have his arms occupied holding a wrapped blanket. During familiarization trials, the walker would consistently walk toward one doorway with the same stimulus sitting on a pedestal behind it. The constant path toward the same stimulus paired with the walker's exclamation provides a plausible object-related goal. Then, during test trials, the stimuli would switch positions and the walker would take either the same path to the new stimulus or a different path to the target stimulus. If infants show a novelty response to the new path, old toy condition, it would provide evidence that walking is encoded primarily as means to an end. Conversely, if they show a novelty response to the old path, new toy condition, the resulting interpretation would suggest that walking is primarily seen as an end in itself.

Of course, in the proposed experiments above, the selected independent variables of age and locomotive history have been overlooked. It seems best to forgo these variables for the time being by using only older, somewhat experienced walkers; if these participants aren't perceiving walking as goal-directed in any means, then it is unlikely that younger infants would be. If the proposed experiments were carried out with findings consistent with the research hypotheses, then it would make sense to follow up with further studies that would examine the developmental emergence of these goal-directed encoding tendencies. It would be the author's speculation that locomotive experience would better predict understanding of the goal-directedness of walking than age. Reasons for this prediction stem from the hypotheses of Woodward and Acredolo and also to an intuitive hunch of the author; new-walkers would seem to be more apt to perceive walking as an end in itself, not only because it does not require a two-step behavioral planning sequence, but also because as infants that have just achieved the important milestone of independent walking, it seems that walking would be intrinsically rewarding in itself. This would contrast with experienced walkers, who already have experience walking and thus are more likely to walk in order to serve further means than to merely walk for the sake of walking.

To conclude, the present study did not find compelling evidence that walking is perceived as goal-directed in infancy. The researchers would like to believe that these null findings were due to the study's shortcomings, not a lack of understanding on part of the participants. With weak evidence that experienced walkers were best at inferring the goal-directedness of another person's walking, the self-experience hypothesis lives on. However, further investigation is necessary in order to determine the true nature of the goal of walking, as well as whether the self-produced behavior accounts of Sommerville and Woodward or Acredolo are more explanative when it comes to the behavior of walking.

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Figure Caption

Figure 1. The two key stimuli used for familiarization and test trials one the presentation tray.

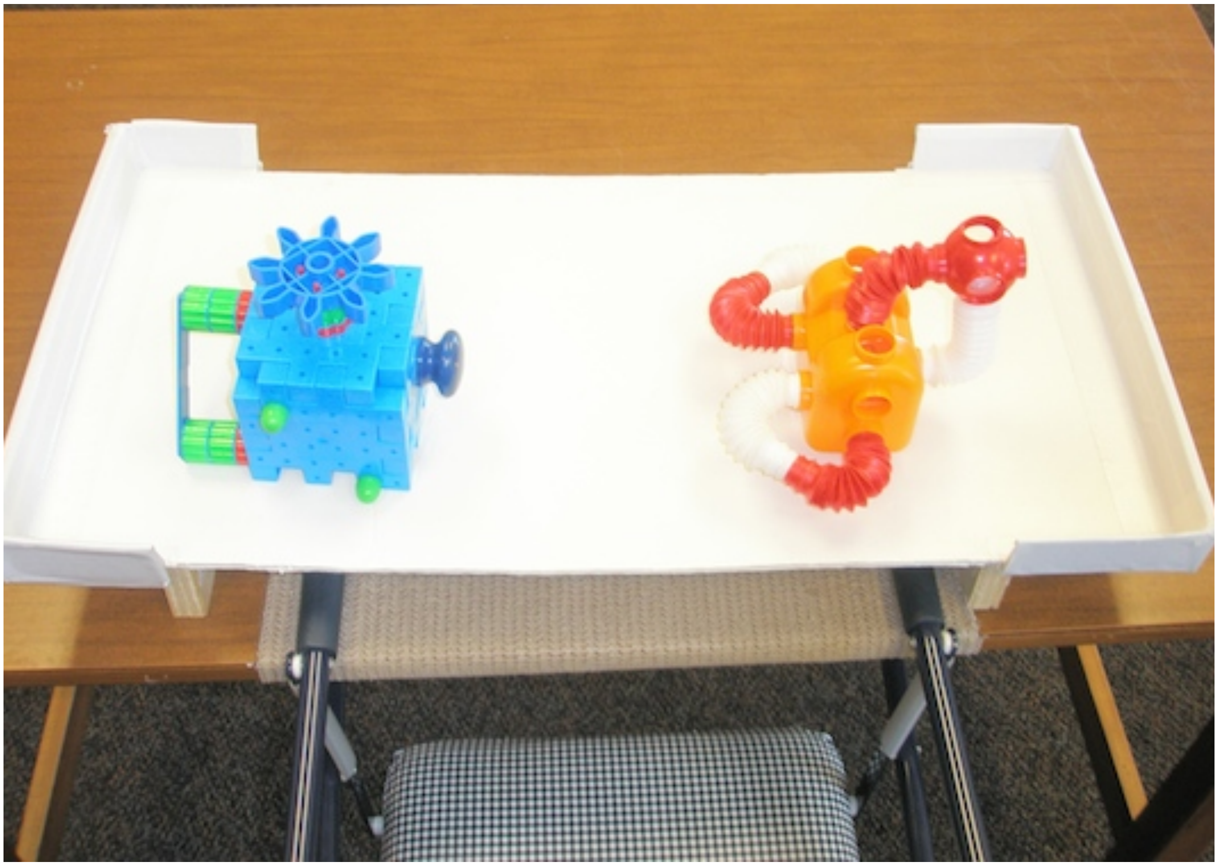

Figure Caption

Figure 2. View of table with infant seat attached and caregiver chair.

Figure Caption

Figure 3. Pedestals with key stimuli on top as seen from just behind the participant's point of view.


GRACO
WARNING

Figure Caption

Figure 4. Experimenter walking toward target stimulus as seen from participant's point of view.

Figure Caption

Figure 5. Experimenter standing next to target stimulus as seen from participant's point of view.

Figure Caption

Figure 6. The assistant handing the experimenter a stimulus from under the table.

Table 1

Frequency Distribution of Favoring as Defined by More Examining Time, by Locomotive Status.

	Examining Time		
	Favored Target	Favored Non-Target	Total
Non-Walkers	5	7	12
Walkers	4	8	12
Total	9	15	24

Table 2

Frequency Distribution of Favoring as Defined by More Looking Time, by Locomotive Status.

	Looking Time		
	Favored Target	Favored Non-Target	Total
Non-Walkers	7	5	12
Walkers	4	8	12
Total	11	13	24

Table 3

Frequency Distribution of Favoring as Defined by First Toy Examined, by Locomotive Status.

	First Toy Examined		
	Target	Non-Target	Total
Non-Walkers	7	5	12
Walkers	7	5	12
Total	14	10	24

Appendix A: Infant Locomotion Questionnaire

INFANT LOCOMOTION

1. Has your infant begun to crawl or creep on the ground (using both legs and arms to transport him/herself)? Yes No

If so, do you know the date at which your infant started crawling? If so, please tell us the date. If not, please approximate to the best of your ability the number of weeks your infant has been crawling:

____

2. Has your infant begun to walk upright with support (holding an adult's hands or holding onto some other support while taking at least 5 steps)? Yes No

If so, do you know the date at which your infant started walking with support? If so, please tell us the date. If not, please approximate to the best of your ability the number of weeks your infant has been walking with support: _____________________________________

3. Has your infant begun to walk upright independently (arms not needing support while taking at least 5 steps)? Yes No

If so, do you know the date at which your infant started walking independently? If so, please tell us the date. If not, please approximate to the best of your ability the number of weeks your infant has been walking with support: _________________________________

4. Does or did your child use an infant walker (wheeled device) that allowed him or her to "walk" by supporting his or her lower body? Yes No

If so, for about how many weeks did your infant use this device before he or she could walk independently, or how long has your infant been using this device? ___________________

Appendix B: Scoring Sheet

GOAL-ORIENTED WALKING SCORING SHEET

Sub. #: ____________ DOB: _______________ DOS: ______________ Gender: _____ Walking?:____________ Condition: _________

Test trial 1a : Social referencing -OR- _________________________

Looks at / Examines																				
Second	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Notes:

Test trial 2a : Social referencing -OR- _________________________

Looks at / Examines																				
Second	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Notes:

Coding variables:
L = Looks at __ O = ____ orange toy
E = Examines ___ B = ____ blue toy