Infants' ability to associate different motion trajectories with animals and vehicles.

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ABSTRACT

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Researchers have postulated that infants use motion cues (e.g., line of trajectory) to distinguish between animate and inanimate objects. However, little empirical research has addressed whether infants associate particular motion cues with object kinds.

The present study examined infants' ability to associate jumping over an obstacle with animals, and hitting an obstacle and rebounding with vehicles. An infant-controlled habituation procedure was used. Sixteen- and 20-month-old infants were habituated to two category-congruent motion events: an animal jumping over a wall and a vehicle hitting a wall and rebounding backwards. During the habituation events, a stationary animal or vehicle was placed on one side of the screen to control for novelty effect of the exemplar in the test events (e.g., if an animal was jumping over the wall, then a vehicle was stationary). Subsequently, infants were presented with two test events. In the congruent test event, the stationary animal or vehicle from the habituation events engaged in the expected motion (i.e., animal jumping or vehicle rebounding). In the incongruent event, the stationary animal or vehicle from the habituation events violated the expected motion path (i.e., an animal rebounding or a vehicle jumping).

The results revealed that by 16 months of age, infants can associate different lines of trajectory with different object kinds, and are surprised when this association is violated. The results are discussed in the context of the recent developmental literature, and infants' conceptualization of animates and inanimates.

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Humans make use of many distinctions to sort the world and organize it into sensible categories. To accomplish this daunting task, numerous categorical distinctions are available, including color, shape, size, texture, and function. In particular, the ability to recognize and categorize objects as animate or inanimate is thought to be one of the most fundamental categorical distinctions available to humans (Gelman & Opfer, in press). This distinction has been referred to in the developmental literature as the animate-inanimate distinction. Animate beings are prototypically thought of as people and animals, while inanimates are prototypically thought of as vehicles, furniture, and other artifacts (Rakison & Poulin-Dubois, 2001). Recently, researchers have claimed that how children come to understand the distinction between animate beings and inanimate objects is one of the most enduring questions in developmental psychology. Furthermore, researchers have also suggested that the origins of the animate-inanimate distinction have relevance for many disciplines within cognitive science (Rakison & Poulin-Dubois, 2001; Woodward, Sommerville, & Guajardo, 2001).

Several findings have led researchers to argue that the ability to recognize objects as animate or inanimate is one of the most basic cognitive processes. Firstly, basic knowledge about whether an entity is an animate or an inanimate object is central to one's reasoning about that entity because it enables formation of different inferences and causal explanations (Gelman & Opfer, in press). For example, knowledge about animate and inanimate category membership affords humans the opportunity to infer that animate beings possess biological properties, such as self-initiated movement, and psychological properties such as intentionality, but inanimate objects do not possess these properties.

That is, based on knowledge about the object's category membership, one can draw conclusions about an object, its features, and its characteristics.

Secondly, the fundamental nature of the animate-inanimate distinction is also indicated by neurophysiological findings. Specifically, animate and inanimate conceptual categories appear to be subserved by distinct neural mechanisms (Caramazza & Shelton, 1998; Gainotti, 2000; Garrard et al., 2001). In particular, these distinct neural mechanisms allow for the selective impairment of animate and inanimate conceptual categories in conditions of brain damage. As a result, cases of selective deficit or sparing of knowledge about living things provide the clearest evidence for neuroanatomical correlates for animate and inanimate categories. For example, the familiar story of "the man who mistook his wife for a hat" describes a man who has sustained damage to the left temporal lobe (Sacks, 1985). In general, most of these cases of selective deficit for living things have sustained damage to the temporal lobe. However, the evidence is not as clear for the category of artifacts (inanimate objects), where lesions associated with this pattern of impairment have been more variable and have typically included fronto-parietal areas but also the temporal lobe in some cases (Caramazza & Shelton, 1998). Overall, it appears that animate and inanimate conceptual categories represent domain-specific knowledge systems that appear to be subserved by distinct neural mechanisms, and thereby their selective impairment in conditions of brain damage results in category-specific deficits.

Thirdly, anthropological research on biological taxonomy suggests that the animate-inanimate distinction is uniform across cultures. According to Atran (1999), humans everywhere classify animals, people, plants, and artifacts into groupings that provide a locus for thinking about biological causes and relations. These ontological categories serve as cognitive mapping, whereby members of the same category tend to display similar linguistic, biological, and psychological characteristics. As a consequence, the folkbiological taxonomy supports a wide range of inductions about living kinds. Furthermore, folkbiological taxonomies are proposed to be the most stable, and widely distributed cognitive structures in any culture. For example, the Itzaj Maya (the last Maya Indians native to the Peten tropical forest of northern Guatemala), and Japanese languages have different lexical terms for classifying objects as animal, plant, or person, as well as terms corresponding to the further sub-classifications equivalent to quadrupeds (e.g., dog and horse), sea animals, and air animals (Atran, 1999). Overall, researchers have concluded that folkbiological taxonomies provide evidence of ontological categorizations (including the categories of animates and inanimates) that are culturally universal, and which serve to support a wide range of inductions about living kinds.

Fourthly, researchers have proposed that the animate-inanimate distinction is well developed by the preschool years, and plays an important role in other aspects of cognitive and linguistic development (Gelman & Opfer, in press). For example, preschoolers use animacy cues to interpret words (Backsheider, Gelman, Martinez, & Kowieski, 1999), to predict how objects will move (Massey & Gelman, 1988), to determine whether animals and objects are alive, and attribute biological processes (such as death) to humans and not to objects (Gelman & Opfer, in press). In fact, preschoolers make very few animistic errors and maintain a firm distinction even in the face of potentially ambiguous entities such as computers and robots (Gelman & Opfer, in press).

Thus, it appears that there is a potent animate-inanimate distinction in place by the preschool age that readily serves as the center of a vast cluster of conceptual distinctions.

Finally, the ability to recognize objects as animate or inanimate is one of the final object distinctions made by adults with Alzheimer's Disease (Hodges, Graham, & Patterson, 1995). For example, adults with semantic dementia lose the distinction between cats and dogs prior to the distinction between animals and vehicles. For this reason, researchers have suggested that it is possible that if this discrimination is one of the last to dissolve, it may be that it is one of the first to develop (Mandler & McDonough, 1998). In summary, because the animate-inanimate distinction may provide a crucial building block for the mind's representation of objects in the world, and appears to be central to a broad array of more complex understandings, it is of empirical and theoretical interest to study when and how it develops.

Recent attempts to delineate the animate-inanimate distinction have maintained that infants distinguish between animate beings and inanimate objects by attending to the motion characteristics of members of these two categories. In particular, Mandler (1992a, 1992b) proposed an influential theory of conceptual development, arguing that infants develop a form of conceptual representation, called an image-schema within the first year of life. Subsequently, the image-schema is the representational format that guides early categorization and concept formation. According to Mandler (1992a, 2000a), these image-schemas are constructed through an innate process of perceptual analysis in which perceptually available motion cues are recoded into a simpler and more accessible kind of meaning. The image-schema then is the representational format that guides early categorization and concept formation. In particular, Mandler has proposed that infants' image-schemas for animates include self-propulsion, a non-linear motion trajectory, contingency of motion without physical contact, and the role of agent in causal interactions. In contrast, the concept of inanimate objects consists of image-schemas that represent movement caused by an outside force, linear motion trajectory, inability to produce action at a distance, and the role of recipient in a causal sequence. Therefore, according to Mandler, these schemas form the basis for the concepts of animate beings and inanimate objects.

Recently, Rakison and Poulin-Dubois (2001) have expanded on Mandler's ideas, and proposed a more complete typology of the motion cues that infants may be using to distinguish between animates and inanimates. Based on their review of the literature, Rakison and Poulin-Dubois proposed that the motion cues used by infants include: (a) onset of motion (self-propelled vs. caused), (b) line of trajectory (irregular vs. smooth), (c) form of causal action (action at a distance vs. action from contact), (d) pattern of interaction (non-contingent vs. contingent), and (e) type of causal role (agent vs. recipient). Overall, Rakison and Poulin-Dubois (2001) concluded that in many cases there is evidence that infants are able to recognize different kinds of motion by 6 months of age (e.g., self-propelled versus caused motion, and agent versus recipient). However, they argue that there is an absence of data revealing that infants differentially associate particular motion cues with the broader categories of animate beings and inanimate objects. That is, there is no evidence revealing that infants develop expectations about relationships that exist between objects, or their attributes, and a physically or psychologically causal characteristic (Rakison and Poulin-Dubois, 2001).

Several findings lend credence to the notion that infants categories of animate beings and inanimate objects are made on the basis of motion characteristics. Firstly, infants are sensitive to motion from birth. For example, researchers (e.g., Slater, 1997) have demonstrated that motion strongly attracts the attention and orientation of very young infants, and infants as young as eight weeks of age are able to distinguish moving and stationary objects. Secondly, neurological evidence indicates that visual perception of biological motion is subserved by a specific neural network (Grèzes et al., 2001; Grossman et al., 2000; Grossman & Blake, 2001). Specifically, it appears that the posterior portion of the superior temporal sulcus and the left intraparietal cortex is involved in the perception of biological motions (Grèzes et al., 2001). Overall, responses to rigid (nonbiological) motion were found to be located posterior to those responses elicited by nonrigid (biological) motions. Thirdly, as was mentioned previously, by the preschool age children have a potent animate-inanimate distinction that serves as the basis for a broad range of conceptual distinctions. Of particular interest is the finding that preschoolers have been found to link motion with their understanding of life. For example, preschoolers expect animals and objects to move differently (Massey & Gelman, 1988), and explain motion by animate and inanimate objects differently (Gelman & Gottfried, 1996). In fact, this association is so robust that 5-year-olds will attribute properties such as hunger and memory (animate properties) to a stimulus of ambiguous identity (a "blob") that moves in an animate, but not an inanimate manner (Poulin-Dubois & Héroux, 1994).

In light of the evidence that preschoolers have knowledge about motions that are characteristic of animates and inanimates and the proposal that motion is central to infants' understanding of the animate-inanimate distinction, developmental researchers have questioned the knowledge about animacy that is present during infancy. Firstly, researchers have examined whether and at what age infants are able to reliably distinguish animates from inanimates. Secondly, Researchers have studied the types of information that infants use to decide whether something is animate or inanimate.

To address whether infants are able to distinguish between animate and inanimate objects, researchers have studied whether and at what age infants recognize that items that vary in appearance all belong to the same category (Gelman & Opfer, in press). For example, researchers have questioned whether infants recognize that an elephant, a horse, and a bird are all members of the category animals. Several studies have tackled this question by presenting infants with several small replicas of members of two categories, simultaneously (Mandler & Bauer, 1988; Mandler, Bauer & McDonough, 1991; Rakison & Butterworth, 1998a, 1998b). This procedure is known as the object-manipulation paradigm. Evidence of infants' categorization is obtained if infants sort the replicas into their respective categories, or if infants touch members of the same category in a sequence that is longer or more frequent than expected by chance. Using this paradigm, infants aged 14 to 30 months have been found to discriminate animals and vehicles as members of two distinct categories (Mandler & Bauer, 1988; Mandler, Bauer & McDonough, 1991; Rakison & Butterworth, 1998a, 1998b).

To examine younger infants' categorization abilities, researchers have used the object-examination task, in which infants are also presented sequentially with small replicas of category exemplars, and the length of infants' examination and physical manipulation of each replica is recorded. That is, infants are initially presented with several members of one category. Subsequently, in the test phase, infants are presented with two objects: a novel member of the same category and a member of the contrasting category. Evidence of categorization is obtained if infants examine the contrasting category member longer than the novel object (same category member). Using this procedure, Mandler and McDonough (1993) have demonstrated that infants as young as 9 months discriminate animals and vehicles as members of two distinct categories. Furthermore, Oakes, Coppage, and Dingel (1997) have also demonstrated the same results with 10-month-old infants. Therefore, one can conclude that by 9 to 10 months of age, infants are able to categorize animals and vehicles.

Although these studies suggest that infants can perceive similarity within category members, and dissimilarity between category members, it is not clear whether these global categories are based on perceptual features or conceptual knowledge (e.g., Mandler, 2000a, 200b; Mandler & McDonough, 1993; Quinn & Eimas, 1996, 2000; Rakison & Butterworth, 1998b; Quinn, Johnson, Mareschal, Rakison, & Younger, 2000). As such, this topic has fueled much debate in the developmental literature. However, Mandler and McDonough (1996; 1998a) have conducted a series of studies that provide convincing evidence that infants have conceptual knowledge of animals and vehicles. In these studies, infants are presented with one exemplar from each of the two categories (e.g., a cat and a bus) and a prop (e.g., a cup) and a baseline measure of behavior is obtained. The experimenter then models an action with a different member of one category (e.g., a dog drinking from a cup). Finally, infants are given the original two exemplars and the prop, and the frequency with which infants perform the action with each exemplar is recorded. Using this generalized-imitation procedure, Mandler and

McDonough (1996) found that 14-month-olds generalized the activities based on category membership and did not extend the activities to inappropriate object kinds. Using a simplified version of the previous procedure, and providing infants with an opportunity to practice imitating the action prior to the generalization task, 9- and 11-month-olds also generalized the action to the same category member during the generalization phase (McDonough & Mandler, 1998a). Thus, infants' generalizations were based on category membership. These seminal studies provide the first evidence that infants' categories of animals and objects are conceptual in nature, and suggest that these concepts are based on activities. However, they do not address Mandler's proposal that infant's concepts of animals and objects are based on motion cues.

In the first step to examine whether infants associate animate and inanimate types of motion with animate and inanimate objects, several studies have investigated whether young infants show awareness of differential motion properties for people and artifacts (e.g., Golinkoff, Harding, Carlson, & Sexton, 1984; Poulin-Dubois, Lepage, & Ferland, 1996; Poulin-Dubois & Shultz, 1988; Spelke, Phillips, & Woodward, 1995). Firstly, Golinkoff and colleagues examined when infants come to realize that only animate objects can move independently or act as agents. Golinkoff et al. (1984) presented 16- and 24-month-old infants with a real chair moving by itself across the room and measured infants' emotional and motor responses. The results indicated that only the older infants responded with surprise, fear, or smiles to the event, and suggested that by the end of the second year, self-propulsion and acting as an agent in a causal sequence is considered anomalous for inanimate objects. Using a live habituation procedure, Poulin-Dubois and Shultz (1988) provide evidence to suggest that this knowledge is present earlier, by the end of the first year. In this study, 8- and 13-month-old infants were seated inside a testing booth and presented with events in which an inanimate object appeared to move on its own or was involved as the agent in a causal sequence. One event involved a chair, which moved from one side of the booth to the other, pulled by a hidden experimenter with invisible plastic strings. The other event featured a self-propelled ball, activated from under a table with a stick. The same events were also presented with a person replacing the ball and chair. The results showed that only the 13-month-old infants habituated to a causal sequence in which an animate object was the agent, but did not habituate to a causal sequence in which an inanimate object was the agent. Based on these results, the authors concluded that an inanimate object playing the role of agent in a causal sequence is considered anomalous at the end of the first year. Furthermore, in an ingenious series of studies by Poulin-Dubois et al. (1996), the reactions of 9- and 12-month-old infants to a series of events in which an unfamiliar inanimate object (a radio-controlled robot) behaved anomalously (e.g., self-propelled, motion controlled at a distance) were compared with infants' reactions when an animate object (a human stranger), behaved similarly. Based on infants' increased negative affect in comparison to baseline (i.e., stationary robot, and stationary human stranger), the results demonstrated that infants consider self-propulsion by a small robot to be anomalous, but not self-propulsion by a human stranger. Thus, the results suggest that infants as young as 9 months are aware of the differential motion characteristics of humans and inanimate objects, and reacted to the incongruous movement of the inanimate object. Additionally, Spelke and colleagues (1995) have elaborated on the findings that infants have begun to reason about human action during the first year, and have suggested that the knowledge underlying this reasoning differs from the knowledge underlying infants' reasoning about inanimate object motion. Thus, taken together, previous research on young infants' ability to associate motion characteristics with animates and inanimates has primarily focused on the animate category of people, and research on infants' knowledge of the motion cues associated with specific categories of animals and objects is limited.

This is an important issue because research has demonstrated that very young infants treat humans differently from non-human animals and objects. For example, by 12 weeks of age, infants look longer at a person's face than at a doll, and by 2 months of age, smile and coo when faced with a responsive adult, but not when faced with a toy monkey (Gelman & Opfer, in press). In particular, the communication-like acts that infants direct toward people versus other objects suggests that infants are aware of differences between people and objects as young as 2 months of age. Nonetheless, it is unclear whether infants' person-object distinction reflects a broader animate-inanimate distinction, or whether it reflects the "special status" of people. Given that infants treat humans and non-human animals differently from a very early age, and the paucity of research investigating specific categories of animals and objects (versus people and objects), it is of interest to examine infants' knowledge of the motion cues associated with non-human animals and inanimate objects.

In the first studies to address this issue, Poulin-Dubois and Vyncke (in preparation) and Baker and Poulin-Dubois (in preparation) have investigated infants' ability to associate one type of motion cue, line of trajectory, with object kinds. Several findings in the research literature suggest that infant's knowledge of motion trajectory is a promising candidate for learning about infants' conceptual animate-inanimate distinction (Baker & Poulin-Dubois, in prep.). First, information about an object's trajectory will frequently be observable at a variety of points in time as an object moves, increasing the probability that infants will attend to this cue. Second, very young infants show good discrimination between motion trajectories. For example, using point-light displays, Bertenthal (1993) and colleagues have demonstrated that 3- and 5-month-olds discriminate between a pattern of lights representing a person walking and a scrambled version of the same light display. Of particular relevance to studies investigating motion trajectory, Sharon and Wynn (1998) have demonstrated that young infants are able to discriminate between different object trajectories as an object moves in space. Specifically, Sharon and Wynn tested whether 6-month-olds discriminate between a "jumping" and a "falling" trajectory. Six-month-old infants were familiarized to events in which a puppet followed one trajectory (e.g., jumping). Then, infants were presented with the puppet moving along both a familiar trajectory (e.g., jumping) and a novel trajectory (e.g., falling), and infants' continued looking time after the event ended was recorded. Infants looked longer at events with the novel trajectory than events with the familiar trajectory, indicating that the infants discriminated between the two trajectories. Research findings have also indicated that 6-month-olds expect fully visible objects to follow a linear path (von Hofsten, Vishton, Spelke, Feng, & Rosander, 1998). Furthermore, when 6-month-olds are shown an object moving on a path that is ocluded at the point of trajectory change, infants quickly learn to anticipate that a particular object will follow a linear path. With greater difficulty, 6-month-olds also learn that a particular object will follow a non-linear path (von Hofsten, Feng, & Spelke, 2000). Taken together, these findings suggest that even very young infants are sensitive to both the relative trajectory of an object's parts, and the trajectory of the object as a whole. Of most relevance to the present study, young infants reliably discriminate between a non-linear or jumping trajectory and another line of trajectory.

In the first study to examine infants' ability to associate object kinds with motion trajectories, Poulin-Dubois and Vyncke (in preparation) used the inductive-inference paradigm to test 14- and 18-month-olds' ability to associate animals and vehicles with two animate motions (climbing stairs, jumping over a block) and two inanimate motions (rolling across a gap, sliding up and down a U-shaped ramp). Infants' choice of the target exemplar increased from baseline to generalization, and was significantly higher than infants' choice of the non-target exemplar in the generalization phase. However, the maximum percentage of correct responses was about 50%; infants frequently did not imitate the motion with either exemplar. Based on these results, it is unclear whether infants do have a clear conceptual understanding of animals and vehicles based on motion, as the task demands may have interfered with infants' performance.

More recently, Baker and Poulin-Dubois (in preparation) tested 12-, 16-, and 20-month-old infants' ability to associate animate beings and inanimate objects with motion trajectories. In a series of experiments, an infant-controlled habituation paradigm combined with a switch design (Werker, Cohen, Lloyd, Casasola, & Stager, 1998; Younger & Cohen, 1986), was used to examine infants' ability to associate trajectory with object kind. Specifically, infants' ability to associate a non-linear (or irregular) trajectory, jumping over an obstacle, with animals and a linear (or smooth) trajectory, hitting an obstacle and rebounding back, with vehicles was tested. Infants were repeatedly presented with an event in which a familiar animal jumped over a wall and an event in which a familiar vehicle hit a wall and rebounded back. When infants' looking time dropped to a criterion level, two test trials were presented, each featuring a new animal or a new vehicle: In the congruent test event, the pairing of category and trajectory was maintained as in the habituation phase, and in the incongruent test event it was violated (e.g., a vehicle jumped over a wall). Baker and Poulin-Dubois (in preparation) predicted that if infants associate object category and motion trajectory, then they should detect the violation of the association between category and trajectory in the incongruent test event, and look longer at it than at the congruent test event. In the first experiment, infants' ability to associate object kind and trajectory was found only at 20 months of age. However, the authors proposed that the late emergence of this understanding might be due to the stimuli used. Specifically, in the events presented to infants, the animals' legs did not move and the vehicles' wheels did not turn. Thus, the stimuli may not have been the most realistic representation of the categories of animals and vehicles, which may have interfered with younger infants' ability to demonstrate their understanding of these categories. Therefore, in Experiment 2, Baker and Poulin-Dubois (in preparation) used stimuli with biomechanical motion and moving parts (i.e., moving legs and moving wheels) to increase the realism of the events and improve the ecological validity of the stimuli. With these experimental modifications, 16-month-old infants looked significantly longer at both the congruent and incongruent test events than at the end of the habituation phase, although there was no difference between infants' looking time at the congruent and incongruent test events. As well, infants looked significantly longer at test events featuring a vehicle than featuring an animal. Given that infants' looking times recovered in the test phase to both test events, the results suggest that the presence of new category exemplars in the test phase may have interfered with infants' performance. That is, infants may have responded to the new animals or vehicles in the events, and may not have been attending to the motion of the objects.

The present study follows directly from Baker and Poulin-Dubois (in prep.) and addresses this concern. Specifically, the present study examines 16- and 20-month-old infants' ability to associate the category of animals with the jumping (non-linear) trajectory, and the category of vehicles with the rebounding (linear) trajectory, <u>controlling for the novelty of the exemplars in the test phase</u>. Firstly, it is hypothesized that infants of both age groups will look longer at the incongruent test event than the congruent test event, indicating that they have associated the category of animals or vehicles with the appropriate motion trajectory (i.e., jumping and rebounding respectively), and are surprised when this association is violated. Secondly, it is hypothesized that there will be a difference in infants' ability to associate object category and motion trajectory as a function of motion. That is, it is predicted that infants' association between object kind and motion trajectory will be stronger for the jumping (non-linear) trajectory than for the rebounding (linear) trajectory, because infants may perceive a vehicle jumping over a wall as more anomalous than an animal walking into a wall and moving backwards.

Method

Participants

The final sample consisted of a total of 48 infants: twenty-four 16-month-olds (M = 16.22 months; SD = 0.36; range: 15.72 to 17.10 months), and twenty-four 20-month-olds (M = 20.32 months; SD = 0.57; range: 19.20 to 21.16 months). There was an equal number of males and females in each group, and infants were from English- or French-speaking homes. All infants had a minimum 35-week gestation period, and did not suffer from any auditory or visual problems, as reported by their parents. Infants in each age group were randomly assigned to either a jumping condition (N = 24) or a rebounding condition (N = 24).

An additional fifteen 16-month-old infants (8 males, 7 females) participated in the study but were excluded from the final sample for the following reasons: failure to habituate (n = 6), fussiness (n = 4), looking at a test trial for less than one second (n = 3), technical difficulties (n = 1), and experimenter error (n = 1). Of the 20-month-olds who participated, an additional twelve (7 males, 5 females) were excluded from the final sample for the following reasons: failure to habituate (n = 4), fussiness (n = 4), looking at a test trial for less than one second (n = 3), and experimenter error (n = 1). A separate sample of eight children was tested (5 males and 3 females, with a mean age of 17.72 months) to pilot-test the procedure.

Infants were recruited from birthlists provided by the Régie Régionale de la Santé et des Services Sociaux de la Région de Montréal-Centre after approval from the Commission d'Accès à l'Information du Québec. Parents were initially sent a letter describing the purpose of the study and inviting them to participate (copy provided in

Appendix A). They were then contacted by telephone to determine whether they were interested in participating.

Stimuli

The experimental stimuli were computer-animated films (created using Director 6.0 for Macintosh and exported into QuickTime™ movies [computer software]) that consisted of four repetitions of a particular event. Each film contained a light blue background, a brown floor, and a dark blue "wall" located in the middle of the screen. In each film, a familiar animal or vehicle (e.g., dog, cat, horse, bus, truck, and car) moved across the computer screen. The animal or vehicle first appeared on one side of the screen and moved forward until it encountered the wall. Then, the animal or vehicle either jumped over the wall and departed the screen on the opposite side, or hit the wall and rebounded backwards, departing the screen on the same side that it entered. The stimuli were created to be as realistic as possible: the legs of the animals and the wheels of the vehicles moved, and when jumping over the wall, the animal or vehicle changed orientation. Refer to Appendix B for still frames from the events.

Two films were presented during the habituation phase. In these films, an animal or a vehicle followed a trajectory consistent with the motion expected of such category: a dog jumped over the wall, or a car hit the wall and rebounded. A total of eight films were created, each consisting of a motion event (i.e., dog jumping or car rebounding), with half of the films presenting the exemplars moving across the screen from left to right, and the other half of the films from right to left. To control for the novelty effect of the category exemplars in the test phase, the animal or vehicle to be presented in the test events was included in each habituation event, as a stationary object on the opposite side of the screen from where the habituation event began. See Table 1 for a list of the habituation events.

Another set of eight films was created for the test phase. A given animal (cat or horse) or vehicle (bus or truck) jumped over the wall in one film and rebounded off the wall in the other film. Thus, each animal and vehicle engaged in a category-appropriate manner in one film (e.g., a cat jumped over the wall; congruent event) and in a category-inappropriate manner in the other film (e.g., a cat hit the wall with its nose and rebounded; incongruent event). See Table 2 for a description of the test events.

An additional film was used to reorient the infant's attention to the screen between trials. This "attention-getter" stimulus consisted of a computer-generated picture of a green circle expanding and contracting as the "ding" of a bell was repeated once per second. Additionally, another film was used as a test of fatigue effect, and was presented to infants prior to the habituation trials and after the test trials. This pre-/post-test film consisted of a computer-generated geometrical shape with moving parts appearing on the left side of the screen, moving across the screen, and exiting the screen on the right side. A still frame of the pre-/post-test is included in Appendix C.

<u>Apparatus</u>

The infant and parent sat in front of a table enclosed on three sides by a black wooden partition. The side panels of the partition measured 203 cm in width by 183 cm in height and were 211 cm apart. The front panel measured 195 cm in width by 183 cm in height, and was at a distance of 165 cm from the infant. The infant sat in a child seat attached to the table, and one of the infant's parents sat directly behind the child. On the table, one metre in front of the child was a colour Apple Multiple Scan 720 Display

Table 1

Events Presented in the Habituation period

Habituation Event	Direction of Motion	Stationary Object
Dog Jumping	Left to Right	Bus
	Right to Left	
Dog Jumping	Left to Right	Truck
	Right to Left	
Car Rebounding	Left to Right	Cat
	Right to Left	
Car Rebounding	Left to Right	Horse
	Right to Left	

Table 2

Congruent and Incongruent Test Trial Events.

Motion	Congruent Event	Incongruent Event
Jumping	Cat Jumping	Bus Jumping
	Horse Jumping	Truck Jumping
Rebounding	Bus Rebounding	Cat Rebounding
	Truck Rebounding	Horse Rebounding

computer monitor (measuring 40.6 cm on the diagonal). Behind the front panel of the black partition, behind the computer monitor, were a Power Macintosh G3 computer, a Sony Trinitron Colour Video monitor (measuring 19.7 cm on the diagonal), and a Sony EVO-120 video camera. The camera lens was placed in an 11 cm circular hole in the partition, located approximately 20 cm directly above the computer monitor, and was focused on the infant's face. During the testing session, the experimenter monitored the infant's visual fixation from behind the front panel, using the video monitor and recording this information by pressing keys on the computer keyboard. The computer program Habit© (version 7.8) was used to present the computer-animated events on the monitor, record infants' looking times, and calculate when the habituation criterion was met. A diagram of the testing apparatus is presented in Appendix D.

Procedure and Design

Participants were greeted by the experimenter and brought to a reception area. The nature and purpose of the study was explained to the parents and any questions were answered. Parents read and signed consent forms and filled out a demographic questionnaire while the experimenter played with the infant. Copies of the consent form and demographic questionnaire are provided in Appendix E and Appendix F, respectively. This familiarization period allowed the infant to become comfortable with the experimenter and the new environment, before testing began. Parents were also provided with instructions for how they should behave during the testing session. A copy of the instructions provided to parents is included in Appendix G. As well, parents were discouraged from redirecting their infant's attention back to the screen and were told that they could smile if their infant turned to look at them.

After the familiarization period (approximately 10 to 15 minutes), participants were brought to the testing room, where the infant was seated in an infant chair attached to the table, and the parent sat directly behind. The lights were dimmed to ascertain that the visual display would attract the child's attention.

The experimental period consisted of 4 blocks of trials: 1 control pre-test trial, a maximum of 16 habituation trials, 2 test trials, and the control post-test trial. Half of the infants in each age group saw films presenting different animals and vehicles, to control for the effect of object preferences. That is, the test object set and test motion were between-subjects variables in the experimental design. An outline of the design is provided in Table 3. Overall, there were four experimental groups, with twelve subjects in each group (i.e., Group A – Jumping, Group A – Rebounding, Group B – Jumping, Group B – Rebounding).

The testing session began with the activation of the attention-getter to draw the infant's attention to the computer screen. As soon as the child looked at the screen, the experimenter pressed a key to stop the attention-getter and begin presentation of the first film. A given event was presented for a maximum of 35 seconds or until the infant looked away from the screen for 1 second, at which time the attention-getter would be displayed prior to presenting the next event.

First, infants were presented with the pre-test trial, which consisted of a geometrical shape with moving parts appearing on the left side of the screen, moving across the screen, and exiting the screen on the right side. Next, infants were presented with a series of habituation trials in which two category-appropriate motion events (a dog jumping from either left to right, or right to left; a car rebounding from left to right, or

Table 3

Experimental Design.

Group	Test Motion	Habituation events	Test events
A	Jumping		
		Dog jumping left to right/Bus stationary	Bus jumping
		Dog jumping right to left/Bus stationary	
		Car rebounding left to right/Cat stationary	Cat jumping
		Car rebounding right to left /Cat stationary	
	Rebounding		
		Dog jumping left to right/Bus stationary	Bus rebounding
		Dog jumping right to left/Bus stationary	
		Car rebounding left to right/Cat stationary	Cat rebounding
		Car rebounding right to left /Cat stationary	
B	Jumping		
		Dog jumping left to right/Truck stationary	Truck jumping
		Dog jumping right to left/Truck stationary	
		Car rebounding left to right/Horse stationary	Horse jumping
		Car rebounding right to left /Horse stationary	
	Rebounding		
		Dog jumping left to right/Truck stationary	Truck rebounding
		Dog jumping right to left/Truck stationary	
		Car rebounding left to right/Horse stationary	Horse rebounding
		Car rebounding right to left /Horse stationary	

right to left) were presented repeatedly until the child habituated to them. That is, all infants were presented with habituation films presenting both the jumping and rebounding motion trajectories (i.e., category appropriate motion trajectories). The order of presentation of the habituation films was semi-random: The first four trials alternated between the two types of motion events, and subsequently, a given event was presented no more than two times in a row. The habituation phase ended when the total looking time during four successive trials was less than 50% of the infant's total looking time during the first four habituation trials, or after a maximum of 16 trials.

Once the infant had habituated, or had seen 16 habituation trials, the test phase began. Each infant saw two test trials: a congruent test event (category-trajectory link was maintained) and an incongruent test event (category-trajectory link was violated). Infants in the jumping group were presented with test events depicting the jumping motion (e.g., cat jumping and bus jumping), while infants in the rebounding group were presented with test events depicting only the rebounding motion (e.g., car rebounding and horse rebounding). Across all test trial pairs, the incongruent event was the first test trial in half of the pairs and the second test trial in the other half, and each animal and vehicle appeared equally often. In all test trials, the animals and vehicles moved from the left side of the screen to the right, and the exemplars used were those that infants had seen as stationary objects in the habituation phase. After the two test trials, each infant was also presented with a post-test trial, which was identical to the pre-test trial.

Coding and Inter-observer Agreement

Infant's looking time at the films during the testing session was coded "live" using Habit© version 7.8 [computer software]. As soon as the child looked at the screen, the experimenter pressed a key to stop the attention-getter and begin presentation of the subsequent film, immediately pressing another key to record the infant's looking at the screen. When the infant looked away from the screen the experimenter took her finger off this second key. The coder was blind to the events that were presented on the computer screen.

The primary experimenter coded the data for infants' looking time at the films. A random selection of 25% of participants was recoded for reliability purposes. Using Pearson product-moment correlations, the mean inter-rater agreement for the infants' looking time for both 16- and 20-month-olds was $\underline{r} = .99$ (range = .95 to 1.00 and .99 to 1.00 for 16 and 20 months, respectively).

Data Screening

Data were screened to assess for outliers, normality, and skewness. Infants with looking times greater than three standard deviations above or below the mean in the films of interest were brought in to within three standard deviations ($\underline{n} = 2$). There was no pattern to these outliers (i.e., they were not specific to any animal or vehicle or trial) and one infant was 16 months and one was 20 months of age. Additionally, as infants' looking times at the test trials were significantly positively skewed, square-root transformations were used to ensure that the data was normally distributed. All reported results reflect findings obtained from analyses of the transformed data, although means and standard deviations provided are based on raw scores.

Results

Habituation

Before examining whether infants had indeed associated the non-linear motion path (jumping) with animals and the linear motion path (rebounding) with vehicles, it was important to confirm that infants had in fact habituated to the films presented in the habituation phase. A 2 (Trial: first habituation block, last habituation block) by 2 (Age: 16 months, 20 months) mixed-model analysis of variance (ANOVA) was used to compare infants' looking time at the first 4 habituation trials and the last 4 habituation trials as a function of age. The mean looking time at the first 4 habituation trials was computed to create the first habituation block, and the mean looking time at the last 4 habituation trials was computed to create the last habituation block. There was a significant main effect of age, $F(1, 46) = 7.76$, $MSE = 1.06$, $p < .05$. Pairwise comparisons indicate that 20-month-olds looked longer at both blocks of habituation trials ($M = 16.35$) than the 16-month-olds ($M = 12.23$), $p < .025$. There was also a significant main effect of trial, $F(1, 46) = 751.49$, $MSE = .08$, $p < .05$, whereby infants looked longer at the first habituation block ($M = 20.22$, $SD = 8.13$) than the last habituation block ($M = 8.37$, $SD = 3.66$). The main effects were qualified by a significant trial by age interaction, $F(1, 46) = 6.83$, $MSE = .08$, $p < .05$. As can be seen in Figure 1, the interaction is due to 20-month-olds looking longer at the first habituation block than 16-month-olds, while there were no differences between the two age groups at the last habituation block. Thus, it was possible to conclude that both 16- and 20-month-old infants habituated to the films presented during the habituation phase, and 20-month-

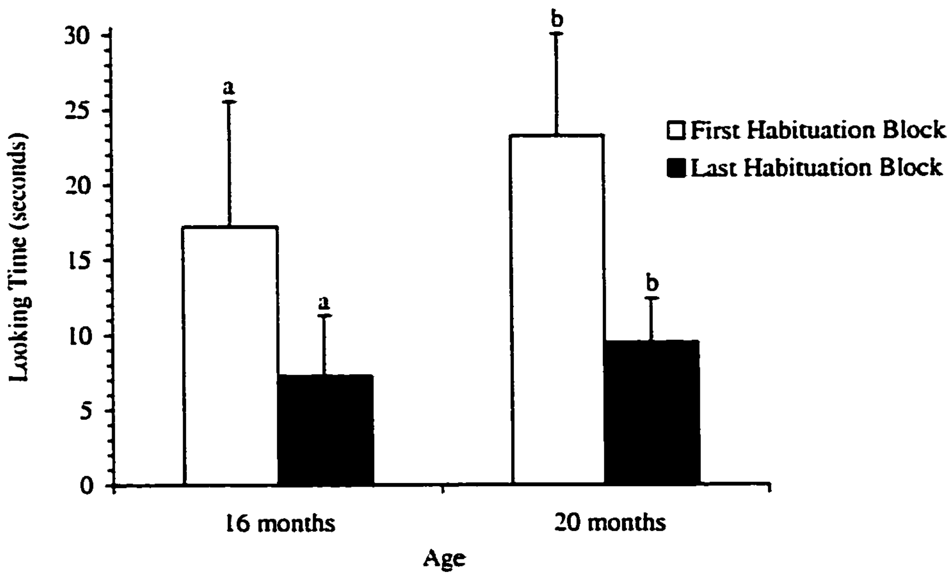

Figure 1. Mean looking times per trial (+SD) at the first and last habituation blocks, for 16- and 20-month-olds. Bars labelled with the same letter differ, $p < .05$.

olds looked longer at the films than 16-month-olds. The ANOVA source table is provided in Appendix H (Table 1).

Fatigue Test

In the second set of analyses, a 2 (Trial: pre-test, post-test) by 2 (Age: 16 months, 20 months) mixed-model ANOVA was used to assess infants' level of fatigue. Infants' looking time at the pre-test and the post-test trials were compared as a function of infants' age to determine the extent to which infants' attention to the films decreased over the course of the testing session. The analysis revealed a significant main effect of trial, $F(1, 46) = 31.63$, $MSE = 1.06$, $p < .05$, whereby infants looked significantly longer at the pre-test ($M = 16.33$, $SD = 10.45$) than the post-test ($M = 7.81$, $SD = 5.06$). As well, there was a significant main effect of age, $F(1, 46) = 7.98$, $MSE = 1.26$, $p < .05$, with 20-month-olds looking longer than 16-month-olds ($M = 14.23$ and $M = 9.92$ respectively). The ANOVA source table is provided in Appendix H (Table 2). However, it is important to note that this comparison is likely to generate cases of false positives for infants' fatigue. That is, it would be expected that most infants would look less during the trials at the end of the testing session than those at the beginning.

Therefore, to obtain a more conservative measure of infants' fatigue during the test trials, infants' looking time at the last block of habituation trials was compared with infants' looking time at the post-test trial. As in the previous analysis, the mean looking time at the last 4 habituation trials was computed to create the last habituation block, and a 2 (Trial: last habituation block, post-test) by 2 (Age: 16 months, 20 months) mixed-model ANOVA was used to compare infants' looking time at these two trials as a function of age. The main effect of trial was not significant. However, as can be seen in

Figure 2, there was a significant main effect of age, F (1, 46) = 6.98, MSE = .72, $p < .05$, with 20-month-olds looking longer than 16-month-olds (M = 9.24 and M = 6.94 respectively). The trial by age interaction was not significant. The ANOVA source table is presented in Appendix H (Table 3). These results suggest that infants may have been fatigued at the end of the testing session. Alternatively, it is possible that the control film used at pre- and post-test may have not been as interesting to infants as the films used in the habituation phase.

Therefore, to examine the possibility that infants may have perceived the pre-/post-test film as less interesting than the habituation events, infants' looking time at the pre-test trial was compared with infant's looking time during the first block of habituation trials. As in previous analyses, the mean of infants' looking time at the first 4 habituation trials was computed to create the first habituation block, and a 2 (Trial: pre-test, first habituation block) by 2 (Age: 16 months, 20 months) mixed-model ANOVA was used to compare infants' looking time at these two trials as a function of age. The main effect of trial was significant, F (1, 46) = 11.67, MSE = .66, $p < .01$, with infants looking longer at the first habituation block than the pre-test trial (M = 20.22 and M = 16.33 respectively). The main effect of age was also significant, F (1, 46) = 8.72, MSE = 1.65, $p < .01$, with 20-month-olds looking longer than 16-month-olds (M = 21.34 and M = 15.21 respectively). The trial by age interaction was not significant. The ANOVA source table is presented in Appendix H (Table 4). These results indicate that even at the beginning of the testing session, infants looked longer at the habituation films than the pre-test trial. It appears that infants were not as interested in the pre-/post-test film as the

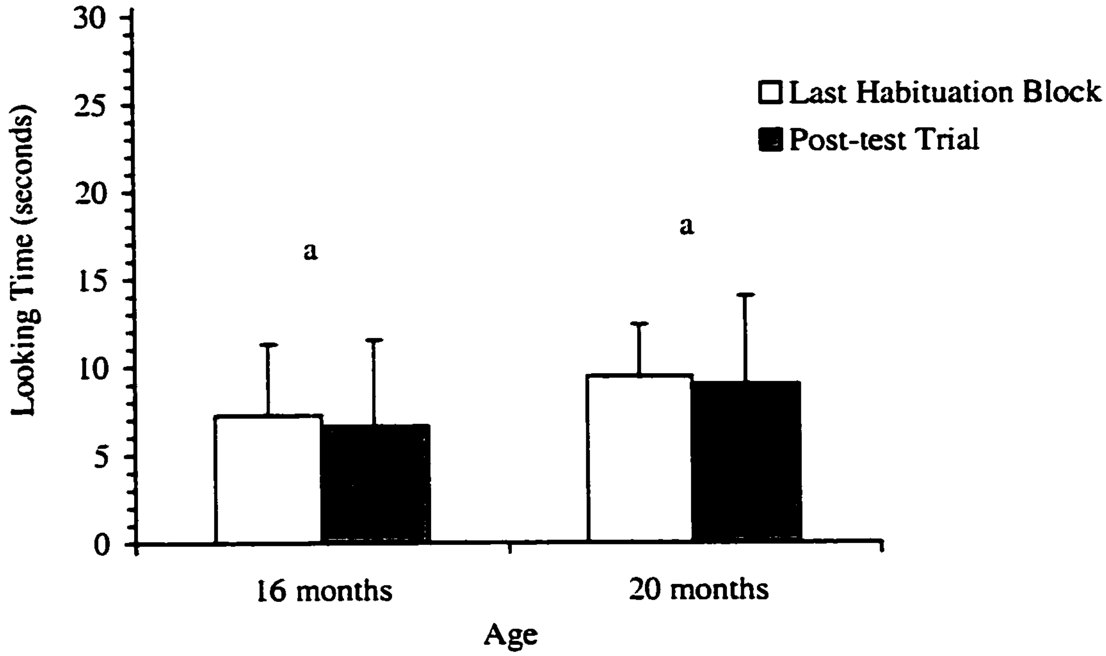

Figure 2. Mean looking times at the last habituation block and post-test trial for 16- and 20-month-olds. Groups labelled with the same letter differ, $p < .05$.

habituation films and thus provides an explanation for the non-significant effect of trial as reported in the previous analysis.

Main Analyses

To address the primary hypothesis of the current study, the main analyses were conducted to examine whether infants associated the non-linear motion path (jumping) with animals and the linear motion path (rebounding) with vehicles. Using a 3 (Trial: last habituation block, congruent event, incongruent event) by 2 (Age: 16 months, 20 months) by 2 (Gender: male, female) mixed-model ANOVA, infants' looking time at the mean of the last four habituation trials, the congruent test event, and the incongruent test event, were compared as a function of infants' age and gender. Age and gender were between-subjects factors and trial was a within-subjects factor. The ANOVA yielded a significant main effect of trial, F (2, 88) = 4.72, MSE = .97, $p < .05$, and a significant main effect of age, F (1, 44) = 5.70, MSE = 1.85, $p < .05$. Again, 20-month-olds looked longer at the trials (M = 12.55) than 16-month-olds (M = 9.14). The effect of gender and the interactions among the factors were not significant. Therefore, the results depicted in Figure 3 are collapsed across gender and age. Furthermore, the ANOVA source table is provided in Appendix H (Table 5).

Follow-up comparisons with a Bonferroni correction (alpha level of .05/3 = .017) were used to examine the trial main effect. As predicted, infants looked significantly longer at the incongruent test event (M = 13.70, SD = 10.47) than the last habituation block (M = 8.37, SD = 3.66), while there was no such difference between the congruent test event (M = 10.47, SD = 8.15) and the last habituation block. Additionally, there was a trend for infants to look longer at the incongruent test event than the congruent test

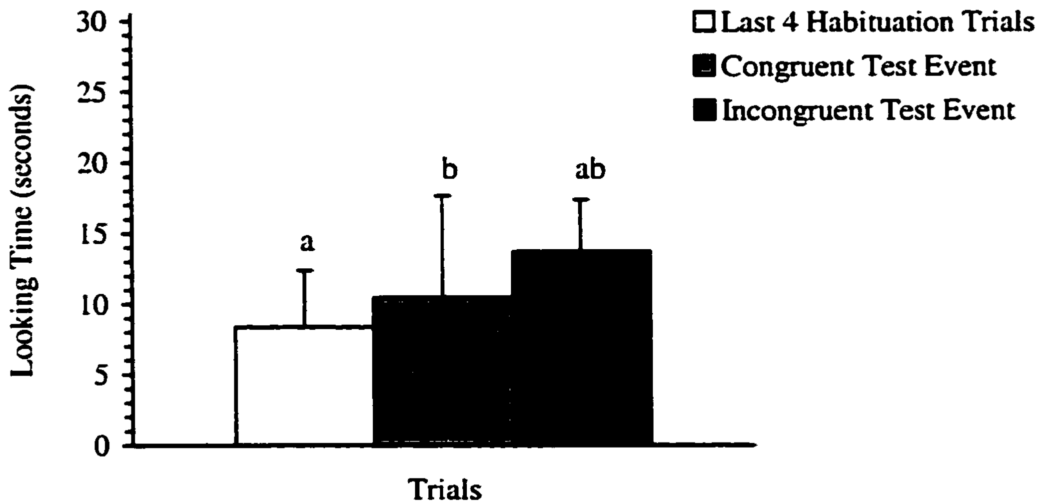

Figure 3. Mean looking times per trial (+SD) at the last 4 habituation trials, congruent, and incongruent test events for 16- and 20-month-olds. Bars labelled with the same letter differ, a: $p < .017$, b: $p < .08$.

event ($p = .08$). These results indicate that infants of both ages associated a non-linear motion trajectory with animals and a linear motion trajectory with vehicles, and were surprised when this link was violated. As well, these results reveal that 16- and 20-month-olds show the same pattern of understanding.

Motion Analyses

Given the prediction that infants' ability to detect a violation between motion trajectory and object category would be stronger for the jumping motion than the rebounding motion, the motion analyses were conducted to examine whether infants' ability to associate motion trajectory with animals or vehicles would be stronger in the jumping condition than in the rebounding condition. Using a 3 (Trial: last habituation block, congruent event, incongruent event) by 2 (Motion: jumping, rebounding) mixed-model ANOVA infants' looking time at the mean of the last four habituation trials, the congruent test event, and the incongruent test event, were compared as a function of the motion trajectory presented to infants in the test phase. As in the previous analysis, the ANOVA yielded a significant main effect of trial, $F(2, 92) = 4.89$, $MSE = .93$, $p < .05$. The main effect of motion and trial by motion interaction were not significant. Means and standard deviations are provided in Table 4, and the ANOVA source table is provided in Appendix H (Table 6).

Again, follow-up comparisons using a Bonferroni correction (alpha level of .05/3 = .017) were used to examine the main effect of trial. The pattern of results is the same as revealed in the main analysis mentioned above. That is, infants looked significantly longer at the incongruent test event ($M = 13.70$) than the last habituation block ($M =$

Table 4

Mean Total Looking Times and Standard Deviations for the Last Habituation Block, Congruent Test Trial, and Incongruent Test Trial, as a Function of Motion.

Motion		n	M	SD
Jumping				
	Last habituation block	24	8.810	3.990
	Congruent test trial	24	11.121	8.946
	Incongruent test trial	24	15.613	11.215
Rebounding				
	Last habituation block	24	7.921	3.332
	Congruent test trial	24	9.825	7.409
	Incongruent test trial	24	11.788	9.509

8.37), while there was no such difference between the congruent test event and the last habituation block. Again, there was a trend for infants to look longer at the incongruent test event than the congruent test event ($p = .08$). Contrary to our hypothesis, these results indicate that there was no difference in infants' ability to associate the motion trajectory with animals or vehicles when comparing the jumping or rebounding conditions.

Object Preferences

Further analyses were conducted to determine whether infants had a preference for one category of objects presented in the test events. If infants have a preference for the animal or the vehicle, then they would look longer at the test event featuring that category exemplar, and it would be unclear whether infants are responding to the violation of the motion trajectory – object kind pairing. A 2 (Category: animal, vehicle) by 2 (Age: 16 months, 20 months) mixed-model ANOVA was used to compare infants' looking time at the test events featuring an animal with test events featuring a vehicle as a function of infants' age. The analysis revealed a significant main effect of age, $F(1, 46) = 3.85$, $MSE = 2.13$, $p = .05$, whereby 20-month-olds looked longer ($M = 14.10$) than 16-month-olds ($M = 10.18$). The main effect of object and the object by age interaction were not significant. Means and standard deviations are presented in Table 5, followed by the ANOVA source table in Appendix H (Table 7). These results indicate that infants looked equally long at test events presenting an animal and a vehicle, and thus did not demonstrate a preference for either the animal or vehicle category.

Table 5

Mean Total Looking Times and Standard Deviations for Test Events Presenting an Animal or Vehicle, as a Function of Infants' Age.

Age	Category	n	M	SD
16 months				
	Animal	24	10.18	9.83
	Vehicle	24	10.18	8.58
20 months				
	Animal	24	12.93	8.87
	Vehicle	24	15.26	10.54

Discussion and Conclusions

Considerable debate in the developmental literature has focused on when and how infants form a distinction between animate and inanimate objects. It has been speculated that motion cues provide the basis for infants' first concepts of animals and vehicles (Mandler, 1992; Rakison & Poulin-Dubois, 2001). Although there is some evidence for infants' perceptual discrimination between motion cues typical of animates and inanimates, the empirical evidence for infants' understanding that these motion cues are associated with different object kinds is sparse. The purpose of the present study was to extend the findings on infants' discrimination abilities, and examine whether infants associate the line of trajectory motion cue with the categories of animates and inanimates. Specifically, the present study examined 16- and 20-month-olds' ability to associate the category of animals with the jumping (non-linear) trajectory, and the category of vehicles with the rebounding (linear) trajectory.

An infant-controlled habituation paradigm was used, in which infants were repeatedly presented with an event in which an animal jumped over a wall and an event in which a vehicle hit a wall and rebounded back. During this habituation phase, another exemplar from the same category as the main character was stationary on one side of the screen, to control for novelty effect of the category exemplar presented in the test phase. When infants' looking time dropped to a criterion level, two test trials were presented, featuring the previously stationary animal or vehicle: In the congruent test event, the pairing of category and trajectory was maintained as in the habituation phase (e.g., an animal jumped over a wall), and in the incongruent test event it was violated (e.g., a vehicle jumped over a wall). It was predicted that if infants have associated the category of animals or vehicles with the appropriate motion trajectory (i.e., jumping and rebounding respectively), infants will only dishabituate to the incongruent test event, indicating that they are surprised when this association is violated. Alternatively, if infants do not associate the categories of animals and vehicles with the jumping and rebounding motion trajectory, there will be no difference between infants' looking time at the two test trials, and trials at the end of the habituation phase. In addition, if infants perceive a vehicle jumping over a wall as more anomalous than an animal walking into a wall and moving backwards, infants' association between object kind and motion trajectory will be stronger for the jumping (non-linear) trajectory than for the rebounding (linear) trajectory. That is, there will be a difference in infants' ability to associate object category and motion trajectory as a function of motion.

The results of the present study revealed that infants of both 16 and 20 months associated a non-linear motion trajectory with animals and a linear motion trajectory with vehicles, and were surprised when this link was violated. Therefore, the results indicate that infants have connected the motion characteristics of line of trajectory with their conceptualization of the categories of animals and vehicles. Moreover, 16- month-olds demonstrate the same pattern of understanding as 20-month-olds, indicating that this association is already in place by 16 months of age. In the earlier study by Baker and Poulin-Dubois (in preparation), only 20-month-olds dishabituated to the incongruent test event, whereas 16-month-olds dishabituated to both the congruent and incongruent test events. Those results indicate that the 16-month-olds detected the presence of novel animals and vehicles in the test phase, but did not react to the motion trajectory – object kind pairing. The present study demonstrates that when the novelty of the exemplar in the test phase is controlled for, 16-month-olds show the same understanding as 20-month-olds.

Furthermore, analyses of the effects for each motion trajectory revealed that there was no difference in infants' ability to detect a violation between motion trajectory and object category as a function of motion (i.e., whether infants saw jumping or rebounding motions in the test phase). That is, infants were equally surprised when the link between object category and motion trajectory was violated for animals and vehicles. In contrast, in the earlier study by Baker and Poulin-Dubois (in preparation), only infants who saw the jumping motion in the test phase appeared to detect the violation of the motion trajectory – object kind pairing, and looked longer at the incongruent event. It is possible that their results reflect the finding that the infants looked longer at events featuring a vehicle than an animal, while there was no such object preference in the present study.

The strength of infants' association appears to be less strong than expected based on the proposal that line of trajectory is one of the motion cues associated with the conceptual categories of animals and vehicles by the end of the first year of life (Mandler, 1992). That is, infants were expected to look significantly longer at the incongruent test event than the congruent test event. However, a direct comparison of looking times at these two events revealed a trend for infants to look longer at the incongruent event than the congruent event. Despite the fact that there is a trend for these test events to be significantly different, it is important to emphasize that while infants dishabituated to the incongruent event, they did <u>not</u> dishabituate to the congruent event, regardless of the fact that a novel event was shown in both cases. Therefore, infants did not dishabituate to the motion trajectory – object kind pairing in the congruent event, although they did in the incongruent event. This indicates that their dishabituation to the incongruent event occurred when the motion trajectory – object kind pairing violated their expectations. However, it is possible that more typical inanimate objects (e.g., furniture) might yield a stronger pattern when directly compared to animals.

Additionally, it is possible that the design of the current study did not allow infants to demonstrate their complete knowledge of this association. Given that computer animations presented the motion events to infants, it is possible that infants did not perceive the events as relevant to real events. As such, their expectations about the association between motion trajectory and object category may not have been as stringent as they would be in a situation more analogous to real events. Alternatively, it is possible that while line of trajectory appears to be a part of infants' conceptual categories of animates and inanimates, its contribution to their conceptual framework for object kinds may not be as strong as other motion cues. That is, when infants are not faced with any other motion cues, they are able to use their knowledge about the association between line of trajectory and object kinds to make the conceptual distinction between animates and inanimates. However, in a real situation, infants are likely to be faced with a number of possible motion cues that act together to inform the infant about an object's category membership, and other motion cues such as self-propulsion and causal role may contribute greater weight to infants' conceptual representation. It is possible that motion cues possessing greater weight in infants' conceptual representations may develop earlier than those cues that have less weight.

Furthermore, the category of vehicles may be a challenging domain for young infants to demonstrate their knowledge of the motion cues associated with object kind.

Specifically, vehicles are an unusual type of inanimate object that defy many of the typical motion characteristics of inanimate objects. For example, vehicles appear to be self-propelled, often move in a noncontingent fashion, and do not always follow a linear trajectory (e.g., planes, motorcycles). Although the present study used cars, trucks, and buses, infant's conceptual knowledge of the category of vehicles may include some of these "atypical" motion characteristics. In fact, given that vehicles comprise an atypical inanimate category, comparing infants' knowledge of motion cues associated with vehicles to that of animals may be a stringent test. Thus, a less stringent investigation may examine infants' knowledge of motion cues associated with other inanimate objects, such as familiar household furniture, or other familiar household items, in comparison to the category of animals.

Overall, the present findings are consistent with the proposals that infants' concepts of animals and vehicles are based on motion cues (Mandler, 1992; Rakison & Poulin-Dubois, 2001). Moreover, this research expands the existing literature by demonstrating a link between motion characteristics and objects kind for the category of animals, whereas prior research in this realm has been restricted to the category of people. In light of these results, future thought-provoking research directions include using other experimental designs (such as the generalized imitation procedure) to address the same research question, and examining the role of infants' knowledge of psychological characteristics (such as intentionality) when conceptualizing animates and inanimates.

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Appendix A

Recruitment Letter

Concordia
UNIVERSITY

May 2001

Dear Parents,

Our research team is currently conducting research on early understanding of animacy, which is funded by the Natural Sciences and Engineering Research Council of Canada. The Commission d'Accès à l'Information du Québec has kindly given us permission to consult birthlists provided by the Régie Régionale de la Santé et des Services Sociaux de la Région de Montréal-Centre. Your name appears on the birthlist of February 2000, which indicates that you have a child of an age appropriate for our study.

At the present time, we would like to invite you and your infant to participate in a research study which we are currently conducting. In the first part of this study, we are examining infants' understanding of the differences between the motion of living beings and the motion of non-living objects. During the study your child will be shown films in which objects move across a computer screen. We will record how long your child looks at the films. The purpose of the second part of the study is to examine infants' conceptual understanding of physical and mental activities. Your child will watch the experimenter demonstrate activities with some toys. Your child will then be asked to imitate those activities with other toys. During the entire study, your child will be sitting in a child seat and you will be seated directly behind. We will videotape your child's responses and all tapes will be treated in the strictest of confidentiality.

Overall, your participation will involve approximately one 45-minute visit to our laboratory at the Loyola Campus of Concordia University, located at 7141 Sherbrooke Street West. Appointments can be scheduled at a time which is convenient for you and your child, including weekends. Free parking is available on the campus and we will reimburse any other transportation costs at the time of your visit. Upon completion of the study, a Certificate of Merit for Contribution to Science will be given to your child, and a summary of the results of our study will be mailed to you once it is completed.

For the purposes of this study, we are looking for infants who are 16 months of age (15.5 to 16.5 months), who hear English or French spoken in the home, and who do not have any visual or hearing difficulties. If you are interested in having your child participate in this study, or would like any further information, please contact Tamara Demke or Sarah Frenkiel at 848-2279 or Dr. Diane Poulin-Dubois at 848-2219. We will try to contact you by telephone within a few days of your receipt of this letter.

Thank you for your interest and collaboration.

Diane Poulin-Dubois, Ph.D.
Associate Professor
Department of Psychology

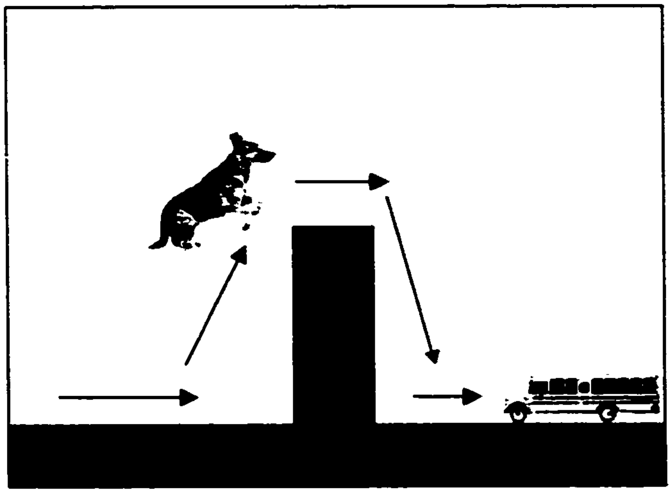
Tamara Demke, B.Sc.
M.A. Candidate

Sarah Frenkiel, B.A.
M.A. Candidate

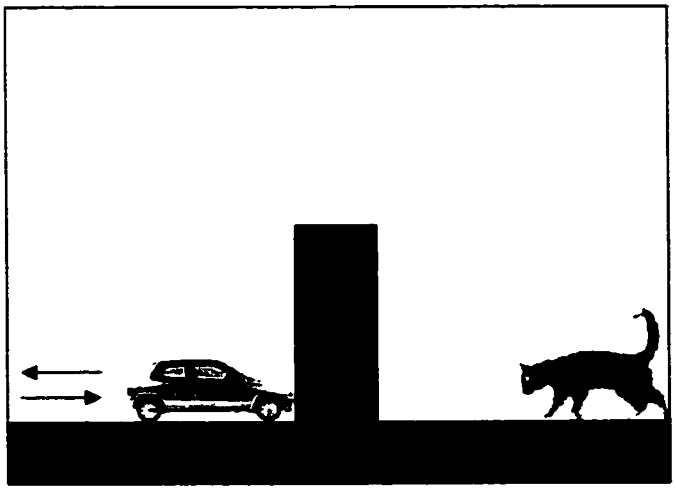
(français au verso)

Appendix B

Sample Movie Frames from Habituation and Test Events

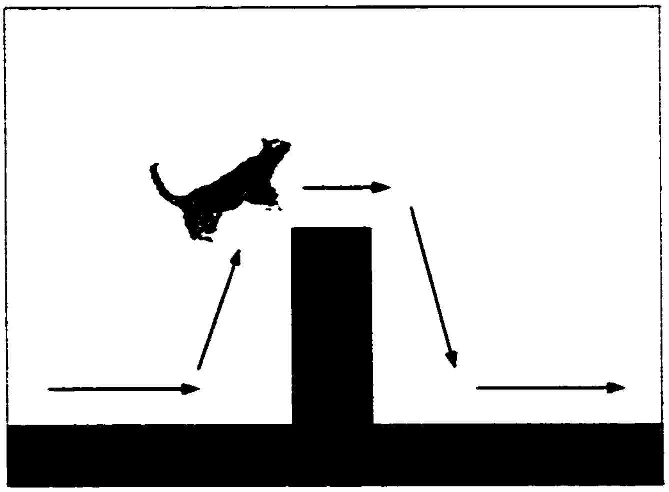


Dog Jumping

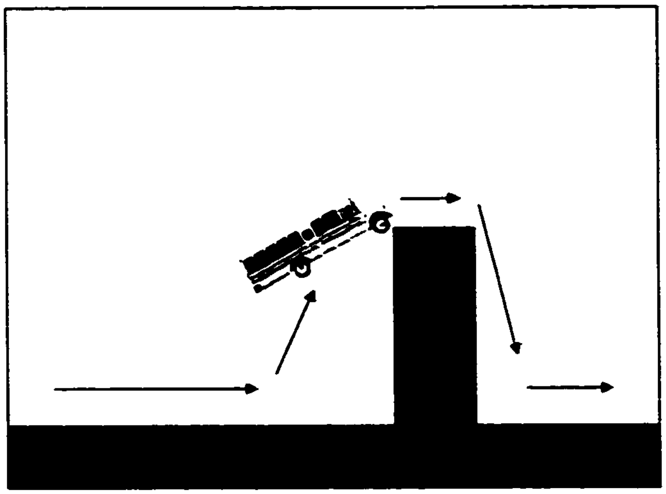


Car Rebounding

<u>Sample Movie Frames from Habituation Events.</u>



Congruent Test Event

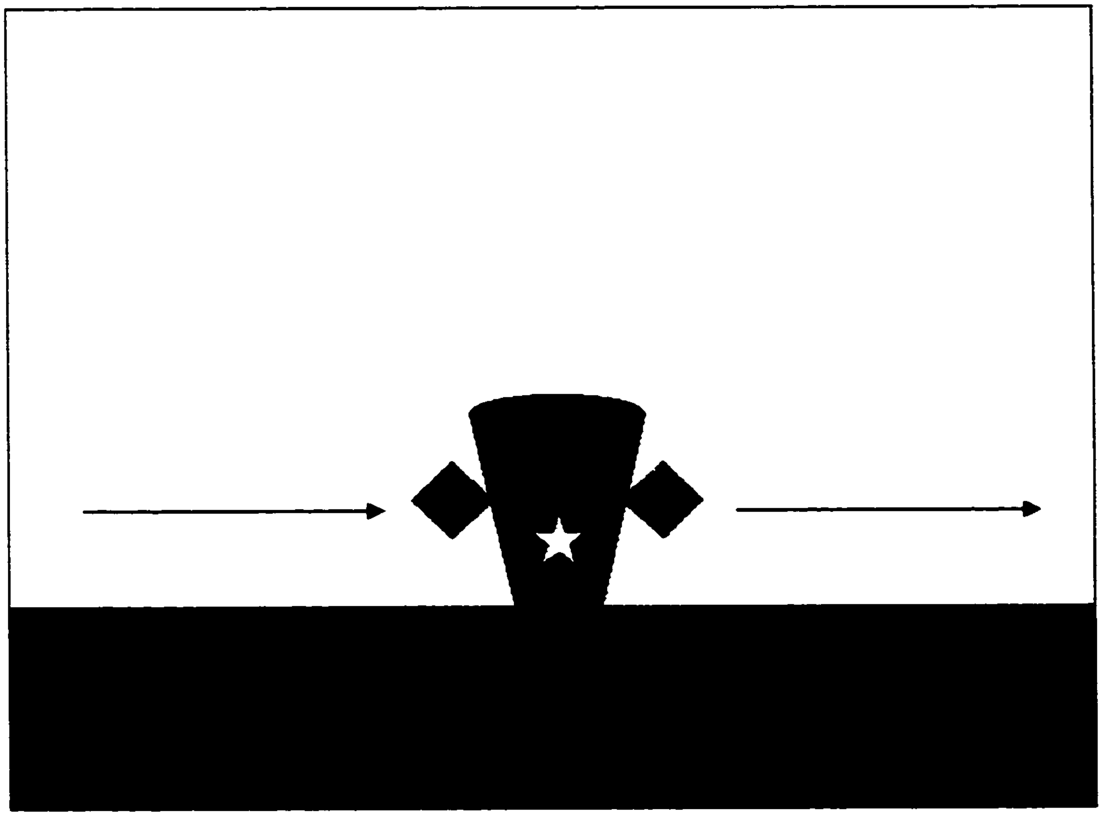


Incongruent Test Event

<u>Sample Movie Frames from Test Events.</u>

Appendix C

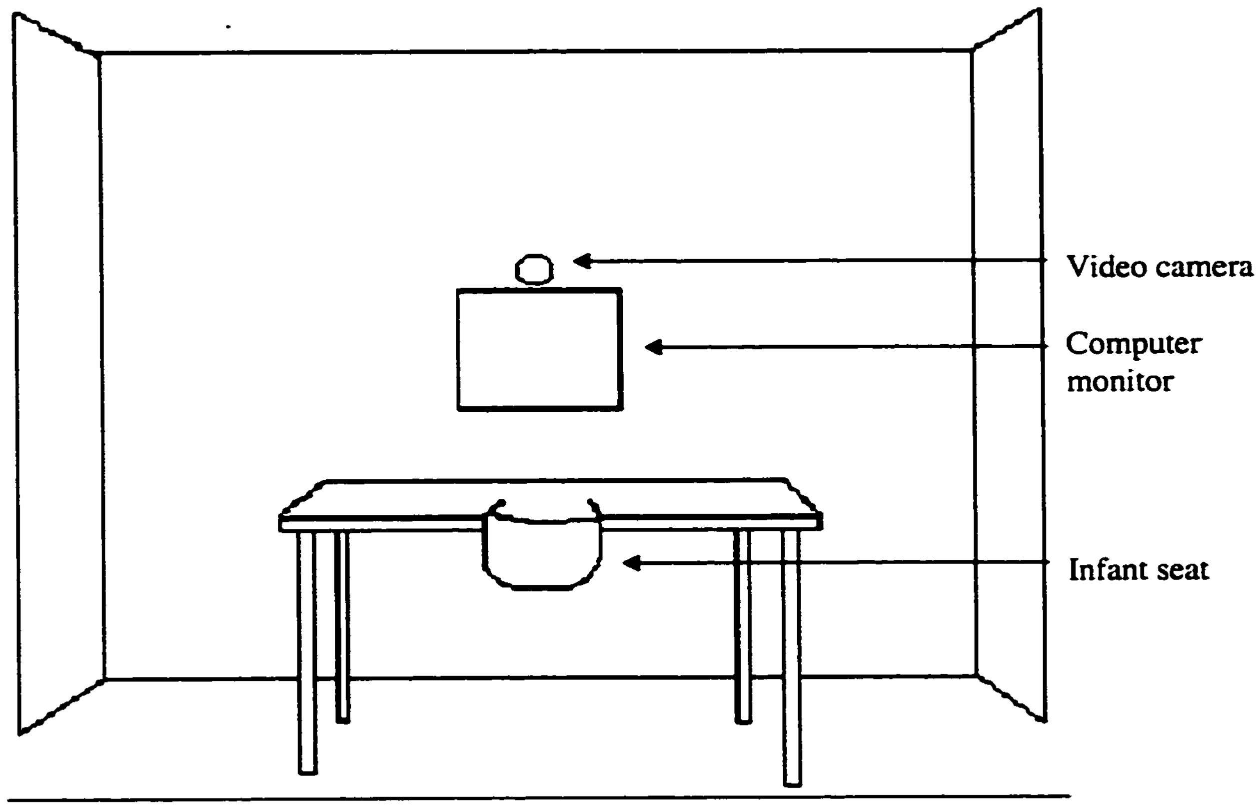
Sample Movie Frame Presented in the Pre- and Post-test Trials



Sample Movie Frame Presented in the Pre- and Post-test Trials

Appendix D

Diagram of Testing Apparatus


Video camera
Computer
monitor
Infant seat

Appendix E

Consent Form

Parental Consent Form

In this study, we are examining how infants distinguish between living beings and non-living objects. More specifically, we are testing their understanding of the motion of members of these two categories. For example, how and at what age do children know that people move differently from chairs? Your child will be presented with animated films on a computer screen and the amount of time your child looks at each film will be measured. Your child will be shown two films repeatedly in which an object moves across the screen until they begin to lose interest in the films. At that time several different films will be shown. You will be asked to remain silent and neutral during the session. The session lasts about 7 minutes and will be videotaped. The videotapes and all the data obtained from them will be kept confidential.

Diane Poulin-Dubois

Diane Poulin-Dubois, Ph.D.
Professor

Tamara Demke

Tamara Demke, B.Sc.
M.A. Candidate

The nature and purpose of this experiment has been satisfactorily explained to me and I agree to allow my child to participate. I understand that we are free to discontinue participation at any time and that the experimenter will gladly answer any questions that might arise during the course of the research.

____________________ Parent's signature

________________ Date

I would be interested in participating in future studies with my child (yes/ no): _________

Subject #: _________

Researcher: ________________

Appendix F

Demographic Questionnaire

Participant Information

Infant's name:____________________ Date of Birth: ____________________

Gender:__________ Language(s) spoken at home:________________________

Mother's name: ____________________ Father's name: ____________________

Address: ________________________ Telephone #:________________home

________________________ ________________work

Postal Code:______________________ ________________work

Mother's occupation:_______________ Father's occupation:_______________

Mother's education (highest level attained):__________________________________

Father's education (highest level attained):__________________________________

Mother's marital status:_____________ Father's marital status:_____________

Please answer the following general information questions about your child:

Birth weight:___________ Length of pregnancy:__________weeks

Birth order:____________(e.g., 1 = 1st child)

Number of siblings:___________

Were there any complications during the pregnancy?__________________________

Has your child had any major medical problems?______________________________

Does your child have any hearing or vision problems? __________________________

Please answer the following general information questions about your family:

Does your family have a pet (or pets)? (yes/no) _______ If you answered yes, please list your pet(s) indicating the kind of pet(s) (e.g., dog, cat, fish) and the number of pets:

____

Subject#:________ Researcher:________________

Appendix G

Instructions Given to Parents

Instructions for Parents

1. When we enter the room where we will be doing the study, please seat your child in the baby seat and sit behind your child in the chair provided.
2. Before we begin the task, please ensure that your child has no toys or food, as these items may be distracting.
3. During the study, please do not interact with your child. Please do not point at the computer screen or speak to your child.
4. Children often look away from the computer screen from time to time during the study. For example, your child will see some pictures many times and may seem bored. If your child turns to look at you, please **ONLY** smile at him/her. Your child will probably turn to look at the computer after a moment.
5. If your child becomes very fussy or starts to cry, we will stop the study so that you can comfort him/her.

Appendix H

ANOVA Source Tables

Table H1

Source Table for Analyses Comparing Infants' Looking Time at the First Habituation Block and the Last Habituation Block as a Function of Age (Trial by Age ANOVA).

Source	df	F
Between subjects		
Age	1	7.758*
Within-group error	46	(1.061)
Within subjects		
Trial	1	751.494*
Trial x Age	1	6.825*
Within-group error	46	(.0795)

Note. Values in parentheses represent mean square errors; asterisks indicate $p < .05$.

Table H2

Source Table for Analyses Comparing Infants' Looking Time at the Pre-test and Post-test Trials as a Function of Age (Trial by Age ANOVA).

Source	df	F
Between subjects		
Age	1	7.975*
Within-group error	46	(1.257)
Within subjects		
Trial	1	31.631*
Trial x Age	1	.634
Within-group error	46	(1.059)

Note. Values in parentheses represent mean square errors; asterisks indicate $p < .05$.

Table H3

Source Table for Analyses Comparing Infants' Looking Time at the Last Habituation Block and Post-test Trial as a Function of Age (Trial by Age ANOVA).

Source	*df*	*F*
Between subjects		
Age	1	6.981*
Within-group error	46	(.719)
Within subjects		
Trial	1	1.666
Trial x Age	1	.027
Within-group error	46	(.423)

Note. Values in parentheses represent mean square errors; asterisk indicates $p < .05$.

Table H4

Source Table for Analyses Comparing Infants' Looking Time at the Pre-test Trial and First Habituation Block as a Function of Age (Trial by Age ANOVA).

Source	*df*	*F*
Between subjects		
Age	1	8.723*
Within-group error	46	(1.652)
Within subjects		
Trial	1	11.673
Trial x Age	1	.055
Within-group error	46	(.663)

Note. Values in parentheses represent mean square errors; asterisk indicates $p < .05$.

Table H5

Source Table for Analyses Comparing Infants' Looking Time at the Last Habituation Block, Congruent Test Trial, and Incongruent Test Trial as a Function of Age (Trial by Age by Gender ANOVA).

Source	df	F
Between subjects		
Age	1	5.699*
Gender	1	1.266
Age x Gender	1	.811
Within-group error	44	(1.848)
Within subjects		
Trial	2	4.723*
Trial x Age	2	.107
Trial x Gender	2	.682
Trial x Age x Gender	2	.138
Within-group error	88	(.967)

Note. Values in parentheses represent mean square errors; asterisks indicate $p < .05$.

Table H6

Source Table for Analyses Comparing Infants' Looking Time at the Last Habituation Block, Congruent Test Trial, and Incongruent Test Trial as a Function of Motion (Trial by Motion ANOVA).

Source	df	F
Between subjects		
Motion	1	1.198
Within-group error	46	(2.027)
Within subjects		
Trial	2	4.890*
Trial x Motion	2	.519
Within-group error	92	(.934)

Note. Values in parentheses represent mean square errors; asterisk indicates $p < .05$.

Table H7

Source Table for Analyses Comparing Infants' Looking Time at the Object Presented in the Test Events (Animal or Vehicle), as a Function of Age (Object by Age ANOVA).

Source	df	F
Between subjects		
Age	1	3.845*
Within-group error	46	(2.132)
Within subjects		
Object	1	.459
Object x Age	1	1.48
Within-group error	46	(1.353)

Note. Values in parentheses represent mean square errors; asterisk indicates $p < .05$.