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# A secret agent? How infants learn about the identity of objects in a causal scene

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**Abstract**

Four experiments examined the role of correlations between dynamic and static parts on 12- to 16-month-olds' ability to learn the identity of agents and recipients in a simple causal event. Infants were habituated to events in which objects with a dynamic or static part acted as an agent or a recipient and then were tested with an event in which the part–causal role relations were switched. Experiment 1 revealed that 16-month-olds, but not 12-month-olds, associate a dynamic part with the role of agent and a static part with the role of recipient. Experiment 2 showed that 12- and 16-month-olds do not associate a static part with the role of agent or a dynamic part with the role of recipient. Experiment 3 demonstrated that 14-month-olds will learn the relations presented in Experiment 1 and Experiment 2. Experiment 4 revealed that 12-month-olds were able to discriminate the two geometric figures in the events. The results are discussed with respect to infants' developing ability to attend to correlations between dynamic and static cues and the mechanism underlying early object concept acquisition.


*Keywords:* Infant cognition; Causality; Animacy; Learning constraints; Object parts

## Introduction

Over the past 20 years, infants' perception and understanding of causality has received increasing attention in the developmental literature. This burgeoning inter-

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est reflects a theoretical consensus that an appreciation of cause-and-effect relations is a cornerstone of the ability to understand the way the world works. In particular, it has been suggested that infants and preschoolers learn that a fundamental difference between animate entities (e.g., people, animals) and inanimate objects (e.g., vehicles, plants, furniture, tools) is that animates tend to be the cause of an action, whereas inanimates tend to be the recipient of an action (e.g., Gelman, 1990; Leslie, 1995; Mandler, 1992; Premack, 1990). Despite this theoretical emphasis on the causal role played by different ontological kinds and recent advances in our understanding of the early perception of causality, little empirical evidence exists concerning when and how infants learn the identity of agents and recipients. A main aim of the experiments presented here was to provide a first step in examining the developmental timetable for this knowledge acquisition and the mechanism that underlies it.

It is now well established that within the first year of life, infants are sensitive to various aspects of causality. Leslie and Keeble (1987), for example, showed $6\frac{1}{2}$- to 7-month-olds a series of simple launching events based on those developed by Michotte (1963). In the direct launching condition, infants were habituated to a green brick-shaped object that moved from left to right across a screen and contacted a red brick-shaped object that then moved in the same direction until off the screen. In the delayed launching condition, infants were habituated to similar events except that there was a short delay between impact and reaction. During the test phase for both conditions, infants were presented with the same basic event they had seen during the habituation phase except that it was reversed. Thus, the brick shapes moved from the right side of the screen to the left side of the screen and the red brick now moved first. The basic rationale for this design was that the reversal of the direct launching event switched the agent–recipient relation and the spatiotemporal properties from those seen during habituation, but the reversal of the delayed launching event affected the spatiotemporal properties alone. Infants at 7 months of age who were habituated to the direct launching event recovered visual attention to the reversal more than did infants who were habituated to the delayed launching event. Leslie and Keeble (1987) interpreted these results to mean that infants in the direct launching condition were sensitive to the causality in the event.

These findings were extended in a clever series of studies by Oakes and colleagues (Cohen & Oakes, 1993; Oakes & Cohen, 1990). Oakes and Cohen (1990) habituated 6- and 10-month-olds to either direct launching, delayed launching, or noncontact events with images of toy objects (e.g., a clown in a car). The direct launching and delayed launching events were identical to those described above. In the noncontact event, infants were habituated to a similar launching sequence except that there was a small gap between the final position of the first object and the starting position of the second object. During the test phase, infants in each condition were presented with the direct, delayed, and noncontact events. The results showed that 6-month-olds looked equally long at all three test events, and this was taken to mean that they did not discriminate causal events from noncausal events. In contrast, 10-month-olds who were habituated to the direct launching event looked longer at the noncausal events, and those who were habituated to one of the noncausal events looked longer at the causal launching event but not at the other noncausal event. The authors interpreted these findings to mean that the ability to perceive causality is not automatic within the first year of life but rather emerges between 6 and 10 months of age (see also Oakes, 1994; cf. Cohen & Amsel, 1998). The same authors also found evidence that infants at 10 months of age can associate specific objects, namely vehicles, with agency (Cohen & Oakes, 1993). This is not to say that infants came to the task with knowledge of vehicles as agents; rather, they most likely learned online the relation between the appearance of the vehicles and their role as agents.

What evidence is there that infants have learned that particular entities or objects in the real world tend to act as the agents or the recipients of an action? Most, if not all, of the existing literature has focused on people, rather than the broader class of animals, as agents. For example, Leslie (1982, 1984) provided preliminary evidence on this issue in a study designed to examine whether infants understand the role of contact in causal events with animate and inanimate objects. In one study with the habituation paradigm, Leslie (1982) showed that 4- and 7-month-olds recovered visual attention when a hand appeared to move a doll without contact. In a related study, Leslie (1984) found that 7-month-olds looked longer when a human hand appeared to pick up a doll without contact but did not look longer at the same event with a wooden block. Similar findings were presented by Woodward (1998, 1999), who found that infants as young as 6 months of age encode a hand reaching for a toy in terms of goal-directed action but do not do so for a mechanical claw that reaches for a toy.

Unfortunately, the few studies that have tested a broader range of agents and recipients have not provided conclusive evidence about the content or structure of infants' knowledge of objects' causal role. One unpublished study by Spelke, Philips, and Woodward (1995), for example, showed that 7-month-olds did not find it anomalous when an inanimate object acted as an agent in a causal event. This could mean that infants at this age have learned that inanimates can be the agent in events or that they have not yet learned that agents tend to be animate entities. Related findings emerged from a study by Golinkoff and Kerr (1978), who tested infants' knowledge of the causal roles performed by animates and inanimates. Infants at 15 and 18 months of age were shown a simple causal event in which the agent in the causal scene alternated between a chair and a man. Somewhat surprisingly, infants in both age groups looked equally long at the event when the chair pushed the man as when the man pushed the chair. This suggests that it is not until at least the middle of the second year that infants associate agency with animates and recipiency with inanimates. It is possible, however, that infants in the study were responding to which object moved first rather than to which object acted as the agent (Cohen, Rundell, Spellman, & Cashon, 1999).

It remains to be seen, therefore, when and how infants learn about the identity of agents and recipients more broadly such that they understand that agents tend to be animals and people and that recipients tend to be furniture, tools, and plants. To address this issue, the theoretical approach taken here builds on that specified by Rakison (2004, in press; Rakison & Poulin-Dubois, 2001, 2002), who suggested that infants may learn initially about motion-related characteristics of animates and inanimates by attending to the correlation between dynamic and static cues. For example, infants may observe a dog moving along a nonlinear trajectory and may associate the legs of the dog with motion along such a trajectory. The claim, then, is that infants start to learn about the motion characteristics of animate entities and inanimate objects by associating specific motion properties (e.g., a motion trajectory) with specific functional object parts (e.g., legs, arms, hands) (Rakison, 2003). After these associations are learned, they act to constrain the aspects of the array to which infants attend. That is, there is a form of constrained attentional learning whereby the represented relations automatically guide attention to similar relations to the exclusion of others (see also Smith, Jones, & Landau, 1996).

Evidence to support this view, at least with regard to how infants learn about objects' distinct motion trajectories, was reported recently in two separate series of studies. Using the habituation paradigm, Rakison and Poulin-Dubois (2002) found that infants at 14 months of age, but not those at 10 months of age, attended selectively to the relation between dynamic cues (e.g., between moving parts and a specific motion trajectory) when a variety of relations were presented. This suggests that the ability to encode correlations between dynamic local cues (those relating to the parts of an object) and dynamic global cues (those relating to the motion of an object itself) may emerge between 10 and 14 months of age. In a novel version of the generalized imitation paradigm, Rakison (in press) found that infants at 18 months of age demonstrated land motions such as rolling and hopping with objects that possessed relevant parts even though the motions were inappropriate for some of the specific objects (e.g., hopping a bed with legs). This was found to be the case even when an ambiguous block was used to model the event. Taken together, these studies suggest that the mechanism for learning about objects' motion properties may be in place between 10 and 14 months of age and that knowledge about real-world objects is acquired, perhaps through application of this learning mechanism, between 14 and 18 months of age. Note that it is possible that infants learn about such properties somewhat earlier than these studies imply; for example, it is feasible that the use of a different experimental task or different stimuli may reveal attention to correlations among dynamic cues in younger infants. However, the important aspect of these results is that the basis for infants' knowledge about the motions of various objects may well be the association between local and global dynamic cues.

How might such a process operate for infants' learning about the identity of agents and recipients? In the real world, agents tend to be animate entities and possess parts that are dynamic when those entities act as agents; people and animals move toward goals and cause a change in the state of those goals, and as they do so fingers grasp, arms reach, legs tread, and mouths open and close. Similarly, the recipients of action tend to be inanimate objects and generally possess static parts or no obvious parts at all; mugs and tools have handles, and balls and pens have a single solid shape. This is not to say that animates are not also sometimes the recipients of an action or that inanimates cannot appear to be the agents of an action. For example, a human can pick up an animal, or a ball can appear to cause another inanimate object to move. Yet in general, the correlation among animacy, agency, and dynamic parts is strong (although clearly not perfect), as is the relation among inanimacy, recipiency, and static parts. Therefore, an associative mechanism that encodes the appearance of objects, in particular the presence of static or dynamic parts, and their roles in causal events could account for how infants initially learn which parts are possessed by agents and which parts are possessed by recipients.

The series of studies reported here were designed to test this hypothesis. The aims of the experiments were twofold. First, the experiments were designed to investigate whether 12- to 16-month-olds can detect and encode the relation between an object's dynamic or static part and its role in a causal event. It is important to note at this juncture that if infants do attend to such relations in the current experiments, this does not necessarily mean that learning about agents and recipients is based on associative processes; instead, such data would show that attention to, and encoding of, the relation between dynamic parts and a causal role is sufficient, but not necessary, for infants to acquire knowledge about the motion properties of different kinds of objects (see the General discussion for more on this issue). Second, the experiments were devised to test whether there is a developmental progression whereby younger infants will process any part relation in a causal event (e.g., when a recipient possesses a dynamic part), whereas older infants, following experience with real-world exemplars, are constrained in the relations they will learn. The idea that early learning about the identity of agents and recipients follows such a trajectory is based on the findings of Madole and colleagues (Madole & Cohen, 1995; Madole, Oakes, & Cohen, 1993). They showed that 14-month-olds will learn any correlation between form and function, whereas 18-month-olds will learn only those correlations that make sense in the real world (e.g., when the form of a part predicts its function). Similarly, Stager and Werker (1997) found that infants at 14 months of age do not use fine phonetic detail in a syllable discrimination task, whereas infants at 8 months of age, who have less word-learning experience, are able to use such detail.

The current experiments used simple direct launching events similar to those used by Leslie (1984) and Oakes and Cohen (1990; see also Cohen and Oakes, 1993). In contrast to previous research, however, the stimuli in each experiment were identical novel geometric figures that differed only with respect to whether they possessed a single static or dynamic part. Geometric figures were used instead of real-world objects because a chief goal of the studies was to examine the mechanism that underpins infants' learning about the identity of agents and recipients and not their knowledge about the causal role that is played by specific objects. Infants were tested at 12, 14, and 16 months of age based on previous findings with similar age groups on causality by Cohen and Oakes (1993) and on form–function correlations by Madole and Cohen (1995; see also Madole et al., 1993). That is, Cohen and Oakes (1993) found that by 12 months of age, infants could associate some appearance features with agency but not with recipiency, and Madole and Cohen (1995) found that by 14 months of age, infants were flexible in the kinds of relations they would encode. Thus, infants at 12 or 14 months of age may learn the part–causal role relations presented in the events used in the current experiments and may be flexible in the relations they are willing to learn. Alternatively, because the relations used here were more subtle than those used by Cohen and Oakes (in their 1993 study the entire appearance of the object was correlated with the role that it played in the event), it is possible that infants in the younger age groups would have difficulty in learning the part–causal role relations presented here.

# Experiment 1

The first experiment was designed to test 12- and 16-month-olds' ability to associate the roles of agency and recipiency with dynamic and static parts, respectively. During the habituation phase of the experiment, infants were presented with a direct launching event in which an object with a dynamic part moved across a screen and contacted an identical object with a static part that then moved in the same direction until off the screen. Infants were presented with two such events: one in which the objects moved from left to right and the other in which the objects moved from right to left. During the test phase, infants were presented with two test events: one that was identical to that seen during habituation and one in which the relations between the causal role and the part an object possessed were switched. Two posttest noncausal events were included to determine whether longer looking to the novel test trial could have resulted from attention to which object appeared first on the screen.

## *Method*

### Participants

The participants were 20 healthy full-term 12-month-olds (mean age 11 months 30 days, range = 11 months 15 days to 12 months 13 days) and 20 healthy full-term 16-month-olds (mean age 16 months 3 days, range = 15 months 21 days to 16 months 9 days). There was an equal number of boys and girls in each age group. The majority of infants were White and of middle socioeconomic status. Data from 10 other infants were excluded from the final sample due to failure to habituate (3 12-month-olds and 3 16-month-olds), to fussing or crying (2), to experimenter error (1), or to technical problems (1). Infants were recruited through birth lists obtained from a private company and were given a small gift for their participation.

### Stimuli

The habituation and test stimuli were computer-animated events created with Macromedia Director 8.0 for PCs. In each event, a geometric figure, which was initially out of sight and off the screen, moved horizontally across a screen and contacted a second geometric figure that was located in the center of the screen. On contact, a "clang" noise was heard and the first figure stopped moving. The second figure immediately began to move in the same direction as the first object and continued to do so until off the screen. The length of time it took each event to be completed was 8 s, and each event could be repeated up to three times per trial. Individual presentations of each event were separated by a blue screen that descended and ascended over a period of approximately 2 s. The two geometric figures in the events were hexagonal red shapes with a green triangular part situated on their tops. The stimuli are illustrated in Figs. 1A and B. The part of one of the figures moved horizontally as the object moved, and the part of the other figure was static. In addition, each figure had a yellow internal star shape to make it more interesting to the infants.

For the habituation trials, events were created in which the first object, or agent, possessed the dynamic part and the second object, or recipient, possessed the static part. The dynamic part moved only when the object to which it was attached moved across the screen. There were two such events: one moving from left to right and one moving from right to left. Fig. 1A presents an example of a direct launching event used during the habituation phase (and as the familiar test event) in which the agent possessed a dynamic part and the recipient possessed a static part. For the test trials, an additional set of events (one from left to right and one from right to left) was generated in which the first object possessed the static part and the second object possessed a dynamic part (Fig. 1B).

Finally, a further four stimuli that portrayed a noncontact event were created for two posttest control trials. The events were identical to those during the habituation phase (first object with dynamic part and second object with static part) and the test phase (first object with static part and second object with dynamic part) except that

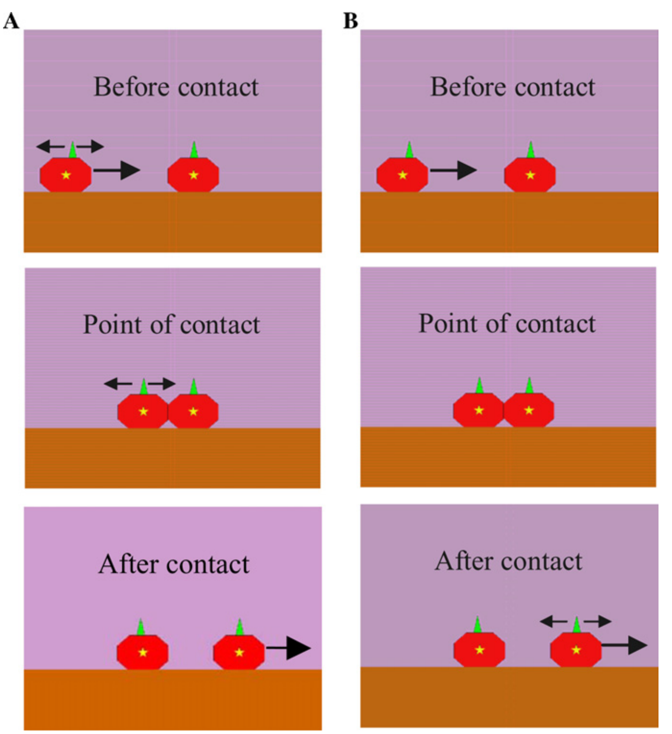


Fig. 1. Example of stimulus events in Experiment 1: (A) habituation/familiar and (B) switch.

the first object did not contact the second object and there was a delay of 1 s before the second object began to move. These posttest noncontact events were used to examine whether longer looking to the novel test trial could have resulted from attention to the first object that appeared on the screen. That is, if infants looked longer at the switch test trial than at the familiar test trial because an object with a static part was the first to appear on the screen (rather than because of the relations between the causal role and the part), they would be expected to also look longer at the posttest switch trial than at the posttest familiar trial. The pattern of looking across the test and posttest trials could also be informative, given the other experiments presented here, about whether infants only notice the motion of the part in the first object when it was an agent.

## Design

The two direct launching events in which the agent possessed the dynamic part and the recipient possessed the static part were used as habituation stimuli. Two events, rather that one, were used during habituation to eliminate the side on which the agent appeared as a variable that could affect infants' looking behavior during the test trials. After habituation, infants were presented with two causal test events and two posttest noncausal test events. One of the test events, the familiar causal event, was identical to one of those observed during the habituation phase. The other test event, the switch causal event, was a direct launching event in which the agent possessed a static part and the recipient possessed a dynamic part. In one of the posttest events, the familiar noncausal event, the first object on the screen possessed a dynamic part and the second object possessed a static part. In the other event, the switch noncausal event, the first object on the screen possessed a static part and the second object possessed a dynamic part. The direction of the test trials (i.e., left to right or right to left) was counterbalanced across the infants in each age group.

A number of predictions were made concerning the 12- and 16-month-olds' looking times during the two sets of test trials. First, based on the notion that infants find dynamic parts especially salient and that by 14 months of age they can form correlations that include two dynamic cues (i.e., parts and a motion path) (Rakison & Poulin-Dubois, 2002), it was predicted that 16-month-olds would look longer at the causal switch test trial than at the causal familiar test trial. Based on previous findings (e.g., Cohen & Oakes, 1993; Madole & Cohen, 1995), it was unclear whether 12-month-olds would learn the relations present in the events. Second, if infants looked longer at the switch test trial because they learned that the first object on the screen possessed a dynamic part, it was expected that they would look longer at the switch noncausal trial than at the familiar noncausal trial.

## Apparatus

Each infant was tested individually in a small, silent, dimly lit laboratory room ($\sim 3.0 \times 2.5$ m). During the testing procedure, events appeared on a 43-cm computer monitor approximately 80 cm from the infant's face. The computer monitor was on a table and was not hidden in any way. At the rear of the monitor, and surrounding the testing chamber, was a black curtain that spread from the ceiling to the floor and across the infant's visual field from left to right. A closed-circuit video camera was located above and behind the monitor and was concealed from view by the black curtain. The video camera made it possible for the experimenter to monitor the infant's looking behavior to the stimuli and to code this visual behavior online. The video camera also recorded the infant's visual fixation so that a second experimenter could later determine a reliability score to verify the initial coding. The experiment was controlled by the Habit 2000 software program (Cohen, Atkinson, & Chaput, 2000) on an Apple G4 computer.

An experimenter, who was out of sight behind the curtain, observed each infant's visual gaze on a television monitor connected to the video camera. The length of a look was recorded by pressing a key on a computer keyboard when the infant attended to the stimulus on the computer monitor. When the infant looked away from the monitor, the experimenter released the key. At the beginning of the experiment, as well as after each habituation and test trial, a green expanding and contracting circle on a dark background was presented on the screen to capture the infant's attention. A bell sound was presented in synchrony with this movement to maximize the attractiveness of the event and to secure the infant's visual attention. After the infant's gaze was toward the computer monitor, the experimenter began the next trial by pressing a preset key on the computer keyboard. The computer recorded the length of each key press, and thereby the visual fixations for each event, and it automatically determined when the habituation phase ended and the test phase began. Because the minimum number of habituation trials was four, after the first four trials had occurred, the experimenter was blind to the exact event presented and whether the event was part of the habituation or test phase.

## Procedure

Each infant was placed facing the computer monitor on his or her parent's lap. The parent was instructed to remain neutral, not to interact with the infant verbally or otherwise, and to focus his or her gaze toward but above the computer screen. This procedure with parents had been adopted successfully in previous studies (e.g., Rakison, 2004; Rakison & Poulin-Dubois, 2002), and it is preferable to using a blindfold or sunglasses because it allows the parent to monitor and soothe a potentially fussy infant. Moreover, the parent was given no information about the hypotheses and predictions of the experiments prior to testing; therefore, it was unlikely that the parent could reliably influence his or her infant's behavior during the test trials. Infants were tested with a version of the subject-controlled criterion habituation procedure. During the habituation phase of the experiment, the infant was presented with two direct launching events, as outlined in earlier sections. Within each age group, the order of the habituation trials was semirandom, with no event appearing more than twice sequentially and with half of the infants receiving one habituation trial first and the other half receiving the other habituation trial first. An event continued until the infant looked away from the monitor for more than 1 s or until 30 s of continuous looking had elapsed. The habituation phase ended when the infant's looking time decreased to a set criterion level or until 16 trials had been presented. To reach the criterion, the infant's looking time on a block of three successive trials had to be less than 50% of the total looking time on the first three trials. At the point where this criterion was reached, or following 16 trials, the test phase began. Infants who did not reach the criterion within 16 trials were excluded from the final analysis. Infants always received the causal test trials before the noncausal test trials because the contrast between the causal familiar and causal switch trials was fundamental to the experimental hypotheses. The order of the familiar and switch test trials, and of the two noncausal posttest trials, was counterbalanced across infants.

### Coding and analyses

The length of each infant's visual fixations was coded by the experimenter's key press and recorded by the computer. A second judge independently recoded 25% of the infants' videotaped looking behavior during the experiment. Interobserver reliability was calculated in two different ways. First, a Pearson product–moment pairwise correlation of the scores coded online and the videotaped trials was computed. Second, the mean difference between the looking time coded by the experimenter and that coded by the second judge on each trial was examined. Reliability for infants' visual fixations in all of the experiments presented here was $r > .97$, and the mean difference between the two judges on each trial was less than 0.29 s.

## *Results*

The mean looking times of the two age groups during the two main test trials and the two posttest trials are presented in Fig. 2. The primary set of analyses investigated infants' looking behavior to the causal familiar and causal switch test events. The looking times were entered into a 2 (Test Event: switch vs. familiar) × 2 (Age: 12 months vs. 16 months) × 2 (Sex: male vs. female) mixed-design analysis of variance (ANOVA). The analysis revealed a main effect of test event, $F(1,36) = 7.48$, $p < .01$, which was mediated by a reliable Test Event × Age interaction, $F(1,36) = 5.43$, $p < .025$. The significant interaction was further examined with a series of planned comparisons. The comparisons revealed that the 12-month-olds looked equally long at the switch ($M = 6.31$, $SD = 5.69$) and familiar ($M = 6.87$, $SD = 6.21$) test trials, $F(1,19) = 0.76$, $p > .50$, whereas the 16-month-olds looked significantly longer at the switch ($M = 12.87$, $SD = 6.00$) than at the familiar ($M = 5.71$, $SD = 5.08$) test trials, $F(1,19) = 16.77$, $p < .001$. There was no significant main effect for age, $F(1,36) = 3.09$, $p > .08$, or sex of the participant, $F(1,36) = 1.02$, $p > .30$, and no significant interaction between these variables.

A second analysis compared infants' performance on the two noncausal posttest trials. The rationale for the inclusion of these trials was to examine whether longer

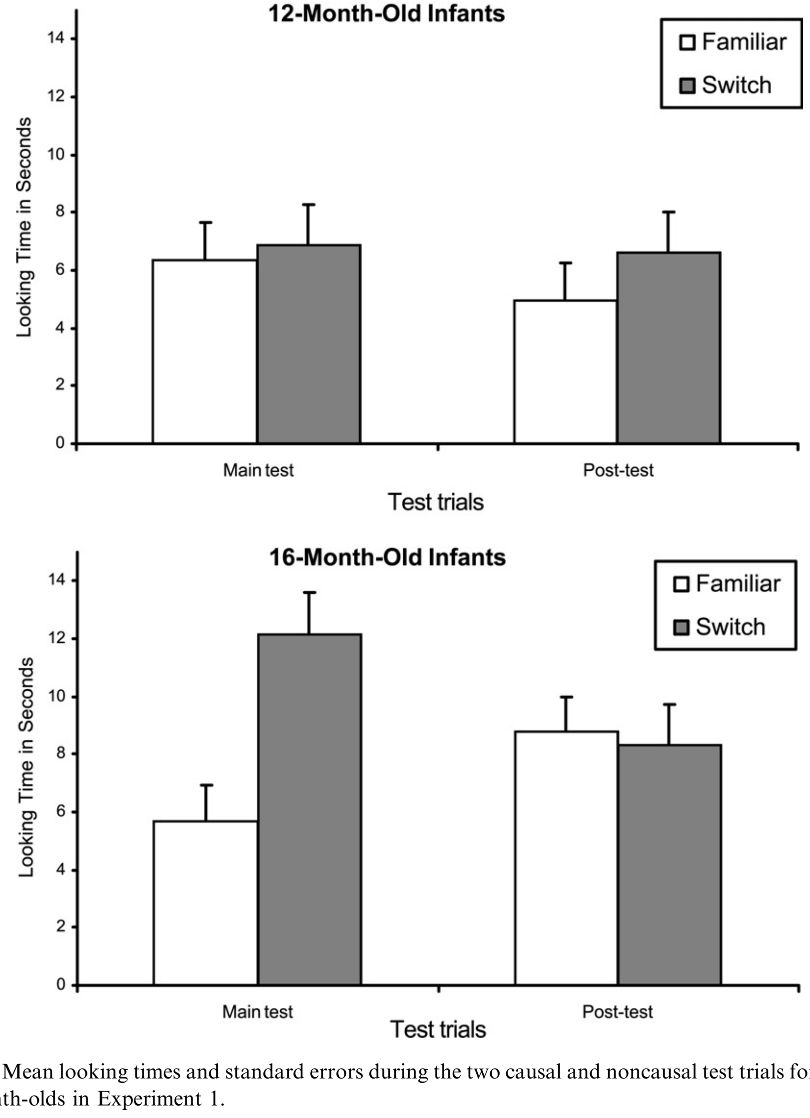


Fig. 2. Mean looking times and standard errors during the two causal and noncausal test trials for 12- and 16-month-olds in Experiment 1.

looking to the noncausal switch event than to the noncausal familiar test event resulted from infants responding to which object appeared first on the screen (the one with the dynamic or static part) rather than from a violation in the part–causal role relations. It was predicted that if infants in the causal test trials were responding to the identity of the first stimulus alone, they would look longer at the noncausal switch event than at the noncausal familiar event because the stimulus with the static part appeared first on the screen in the former but not in the latter. It was also predicted that if infants' pattern of looking on the two main test trials was not based on which object appeared first on the screen, they would look equally long at both control events. The looking times for the two posttest trials were examined with a 2 (Posttest Event: switch vs. familiar) $\times$ 2 (Age: 12 months vs. 16 months) $\times$ 2 (Sex: male vs. female) mixed-design ANOVA. The analysis revealed no main effect of event, $F(1,36) = 0.19$, $p > .50$, or age, $F(1,36) = 3.60$, $p > .06$, and no significant interaction between these variables. There was also no main effect for sex of the participant ($p > .30$). Thus, infants in both age groups looked equally long at the two noncausal events. This suggests that infants' visual fixations for the two test events were not overly influenced by which object appeared first on the screen.

A final analysis compared infants' looking times to the familiar causal event and the first noncausal event presented during the test phase. The rationale for this analysis was to determine whether infants, as in previous studies with a similar design (e.g., Oakes & Cohen, 1990), discriminated causal launching events from those in which a causal relation was absent. The data were entered into a 2 (Trial Type: familiar causal test vs. first noncausal test) $\times$ 2 (Age: 12 months vs. 16 months) $\times$ 2 (Sex: male vs. female) mixed-design ANOVA. The analysis revealed a main effect for trial type, $F(1, 36) = 4.53$, $p < .05$, which indicated that across the two age groups infants looked reliably longer at the first noncausal test trial (overall: $M = 8.90$, $SD = 6.55$; 12 months: $M = 7.73$, $SD = 6.27$; 16 months: $M = 9.92$, $SD = 7.27$) than at the familiar causal test trial (overall: $M = 6.04$, $SD = 5.33$; 12 months: $M = 6.31$, $SD = 5.69$; 16 months: $M = 5.71$, $SD = 5.08$). There were no further significant main effects or interactions. Thus, infants distinguished between the causal and noncausal events presented in the experiment, and the failure of the 12-month-olds to learn the available part–causal role relations could not be attributed to an inability to perceive the habituation events as causal.

### *Discussion*

Experiment 1 was designed to examine whether infants are able to associate the causal role of an object with a single part, namely a dynamic or static part. The results reveal that 16-month-olds, but not 12-month-olds, learned the relation between the type of part that an object possessed and whether that object acted as an agent or as a recipient in a simple causal event. In other words, infants learned either that the object with the moving part was the agent in the event, that the object with the static part was the recipient in the event, or both of these relations. Infants were able to make such attributions of the causal role even though the objects were identical in every way except for whether they possessed a dynamic or static part. The noncausal test trials confirmed that 16-month-olds' longer looking to the switch test trial could not be attributed to attention solely to the first object on the screen.

Although this experiment provides a first step in establishing how infants may learn about the identity of objects that play distinct roles in a causal scene, it leaves a number of questions unanswered. First, it remains to be determined whether 16-month-olds' behavior in the experiment was based on prior knowledge of agents or recipients or on online learning about the specific stimuli in the events. One possible explanation for the 16-month-olds' behavior in the experiment is that the stimulus events tapped their knowledge of real-world relations involving agents and recipients. That is, by 16 months of age, infants may have learned that in the real world things that act as agents tend to have dynamic parts, whereas things that act as recipients tend to have static parts. Geometric figures were used here to minimize the possibility that prior experience with the exemplars affected infants' behavior; however, the stimuli embodied relations similar to those found in the real world. Therefore, the events to which infants were habituated would have fit their already developing knowledge about relations between the causal role of an object and its appearance. An alternative explanation is that infants at 16 months of age may have known little about the properties of objects that play different causal roles and instead may have learned online, during the habituation procedure, that the agent in the event possessed a dynamic part and the recipient possessed a static part. If this interpretation were shown to be accurate, it would suggest that the mechanism for learning about relations between global and local dynamic cues is operational and can encode such relations rapidly by 16 months of age. Experiment 2 was designed to address this issue.

## Experiment 2

In the second experiment, infants were tested with the same basic design as that used in the first experiment with one important exception, namely that during the habituation phase the agent possessed a static part and the recipient possessed a dynamic part. Infants were then tested with an event that violated the relations between the causal role and the part of an object and a familiar event that maintained these relations. The rationale for this design was that infants would fail to encode the causal role of each object with the type part it possessed if they had learned that in the real world agents possess dynamic parts and recipients possess static parts. That is, it was expected that infants' knowledge of real-world relations would constrain the relations they were willing to learn in the laboratory. In contrast, if infants had not yet learned about the nature of real-world relations involving causal events, they would likely encode any relations among dynamic cues with which they were presented, even those that do not make sense in the real world. A similar reasoning was applied by Madole and Cohen (1995), who found that 14-month-olds learned any correlation between the form of a part and the function of a part, whereas 18-month-olds learned only those correlations that made sense in the real world (e.g., when form predicts function). Infants at 12 and 16 months of age were again the participants.

### *Method*

#### Participants

The participants were 16 healthy full-term 12-month-olds (mean age 11 months 26 days, range = 11 months 13 days to 12 months 15 days) and 16 healthy full-term 16-month-olds (mean age 16 months 1 day, range = 15 months 16 days to 16 months 14 days). There was an equal number of boys and girls in each age group. Data provided by 11 additional infants (5 12-month-olds and 6 16-month-olds) were not included in the final sample due to a failure to habituate (6), to fussing or crying (4), or to experimenter error (1). Infants were recruited in the same way as in Experiment 1 and were given a small gift for their participation.

### Stimuli, design, apparatus, and procedure

The stimuli were identical to those used in Experiment 1 with the exception that during the habituation phase infants were presented with direct launching events in which the agent possessed a static part and the recipient possessed a dynamic part. Following habituation, infants were tested with a familiar causal event that was identical to one of those observed during the habituation phase and a switch causal event in which the agent possessed a dynamic part and the recipient possessed a static part. The posttest noncausal test control events were identical to those used in Experiment 1. The apparatus and procedure were identical to those employed in Experiment 1.

## *Results*

As in Experiment 1, the first analysis investigated infants' visual fixation to the familiar and switch test events. The looking times were entered into a mixed-design ANOVA with test event (switch vs. familiar) as the within-subjects factor and age (12 vs. 16 months) and sex (male vs. female) as the between-subjects factors. The analysis revealed no main effect of test event, $F(1,28) = 0.59$, $p > .40$, age of the participant, $F(1,28) = 1.68$, $p > .20$, or sex of the participant, $F(1,28) = 1.91$, $p > .20$. There was also no significant interaction between any of the variables. The mean looking times of the two age groups during the two causal test trials and the two noncausal posttest trials are presented in Fig. 3.

A second analysis compared infants' performance on the two noncausal test trials. Looking times were entered into a 2 (Posttest Event: switch vs. familiar) $\times$ 2 (Age: 12 months vs. 16 months) $\times$ 2 (Sex: male vs. female) mixed-design ANOVA. The analysis indicated that across the two age groups, infants looked equally long at the switch ($M = 6.70$, $SD = 6.01$) and familiar ($M = 7.18$, $SD = 6.10$) posttest events, $F(1,28) = 0.12$, $p > .60$. There was no reliable difference in looking times between the two age groups, $F(1,28) = 0.86$, $p > .30$. There was also no significant effect for sex of the participant or any interaction between the variables.

A third analysis compared infants' looking times to the familiar causal event and the first noncausal event. The data were examined with a mixed-design ANOVA with trial type (familiar causal test vs. first noncausal test) as the within-subjects factor and age (12 months vs. 16 months) and sex (male vs. female) as the between-subjects factors. In contrast to Experiment 1, the analysis revealed no significant main effects or interactions among the variables. Further inspection of the data suggested that the failure to find any significant effect might have resulted primarily from the 16-month-olds' pattern of looking. In support of this view, additional analyses indicated that 12-month-olds looked significantly longer at the noncausal event ($M = 10.13$,

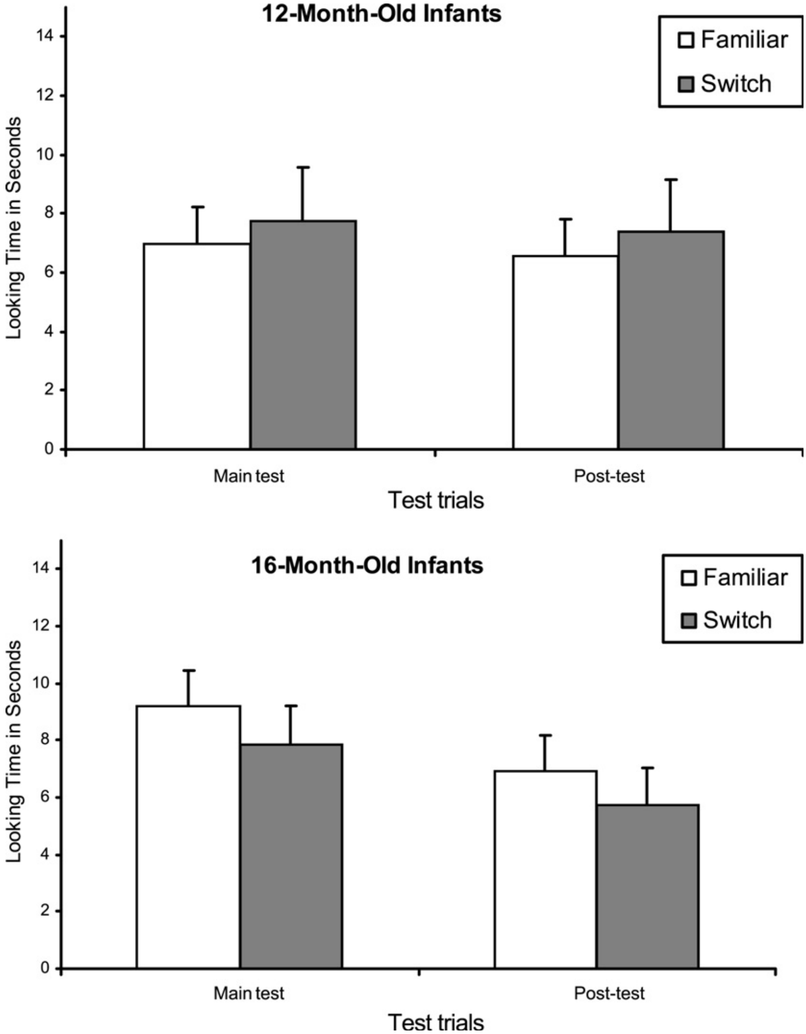


Fig. 3. Mean looking times and standard errors during the two causal and noncausal test trials for 12- and 16-month-olds in Experiment 2.

$SD = 3.50$) than at the causal event ($M = 6.95$, $SD = 3.97$), $t(15) = 2.16$, $p < .05$, whereas 16-month-olds looked equally long at both kinds of events (causal: $M = 9.23$, $SD = 5.63$; noncausal: $M = 9.05$, $SD = 6.67$), $t(15) = 0.09$, $p > .50$. This suggests that infants at 12 months of age perceived the events as causal but that infants at 16 months of age did not; however, it is worth noting that the 16-month-olds' failure to look longer at the noncausal trial might have resulted from relatively long looking to the familiar causal trial.

A final set of analyses compared infants' behavior across Experiment 1 and Experiment 2 on the causal test trials. Looking times for each group were examined separately with a 2 (Condition: dynamic agent vs. dynamic recipient) × 2 (Test Trial: switch vs. familiar) × 2 (Sex: male vs. female) mixed-design ANOVA. The analysis for the 12-month-olds revealed no significant main effects or interactions among the variables, suggesting that their performance was equivalent across the two experiments. That is, they did not learn the part–causal role relations in either experiment. In contrast, the analysis for the 16-month-olds revealed a main effect for condition, $F(1,32) = 4.49$, $p < .05$. This effect was mediated by a significant interaction between condition and test trial, $F(1,32) = 10.43$, $p < .005$, indicating that infants looked longer at the switch test trial than at the familiar test trial in Experiment 1 but looked equally long at the two test trials in Experiment 2.

### *Discussion*

Experiment 2 was designed to determine whether the behavior of infants in Experiment 1 was influenced by prior experience of the parts that are characteristic of agents and recipients. Of issue was whether 16-month-olds' ability to learn that an agent possesses a dynamic part and a recipient possesses a static part was facilitated by their knowledge that these relations are typical of real-world objects. To address this matter, infants at 12 and 16 months of age were habituated to events in which the relation between an object's causal role and its part were inconsistent with those found in the real world. It was predicted that if infants prior to testing had not yet learned that agents tend to possess dynamic parts and that recipients tend to possess static parts, they would learn the relations presented in the events. It was also predicted that if infants prior to testing had learned that agents tend to possess dynamic parts and that recipients tend to possess static parts, they would not learn the relations presented in the events.

As in Experiment 1, the results showed that 12-month-olds did not associate the part an object possessed with the role it played in a causal event. However, in contrast to the findings of Experiment 1, 16-month-olds did not learn the relations presented in the event. That is, they did not associate the dynamic part with the recipient of the causal action and the static part with the agent of the action. This latter finding is in line with the results of Madole and Cohen (1995). That is, presumably because of older infants' greater experience with causal events and with agents and recipients, they will encode only relations that are consistent with those in the real world. That infants at 16 months of age did not look longer at the first noncausal test trial than at the familiar causal test trial is consistent with previous work by Cohen and Oakes (1993) that showed that infants do not respond to causal versus noncausal test events on the basis of causality when the identity of the objects changes in each trial. Thus, when early information processing abilities are taxed by the demands of the task, as they were here by the inconsistency of the part–causal role relations with those in the real world, infants are less likely to attend to the causality of an event.

The results presented so far suggest that 16-month-olds are constrained in the relations they are willing to learn by their real-world knowledge. However, it is also important to examine whether younger infants, who are at an age where they are capable of encoding the causal events used in Experiments 1 and 2, are unconstrained in the part–causal role relations they will learn. Madole and Cohen (1995), for example, showed that 14-month-olds, but not 18-month-olds, learned the correlation between the form of a part and the function of a part even when the form did not predict the function. This issue was investigated in Experiment 3.

## Experiment 3

In the third experiment, 14-month-olds were tested with the same events used in Experiments 1 and 2. One group of 14-month-olds were habituated with events in which the agent possessed a dynamic part and the recipient possessed a static part, and another group of 14-month-olds were habituated with events in which the agent possessed a static part and the recipient possessed a dynamic part. It was predicted that infants in both groups would learn the part–causal role relations if they were capable of encoding these kinds of events, as previous research suggests (Rakison & Poulin-Dubois, 2002), and if they had limited experience of such relations in the real world. However, if infants were unable to encode the relations in the events, as was the case for 12-month-olds in the first two experiments, they would be expected not to learn either of the relations in the different events. Finally, if 14-month-olds had knowledge of real-world relations, it was predicted that this knowledge would constrain the relations they would learn in the laboratory and that their performance would be similar to that of the 16-month-olds in Experiments 1 and 2.

### *Method*

### Participants

The participants were 32 healthy full-term 14-month-olds (mean age 14 months 3 days, range = 13 months 15 days to 14 months 14 days). There was an equal number of boys and girls. Data provided by 8 additional infants were not included in the final sample due to a failure to habituate (3 from the dynamic agent condition and 2 from the dynamic recipient condition), to fussing or crying (2), or to experimenter error (1). Infants were recruited in the same way as in the previous experiments and were given a small gift for their participation.

### Stimuli, design, and procedure

The stimuli were identical to those used in Experiments 1 and 2. Infants were randomly assigned to one of two conditions. In one condition (dynamic agent), 16 infants were habituated and tested with the events used in Experiment 1; in the other condition (dynamic recipient), 16 infants were habituated and tested with the events used in Experiment 2. All aspects of the stimuli, design, and procedure were identical to those of Experiment 1 for the first condition and to those of Experiment 2 for the second condition.

### Results

The first analysis compared infants' looking times to the familiar and switch test events in the two conditions. The looking times were entered into a mixed-design ANOVA with test event (switch vs. familiar) as the within-subjects factor and condition (dynamic agent vs. dynamic recipient) and sex as the between-subjects factors. The analysis revealed a main effect of test event, $F(1,28) = 13.50$, $p < .001$, indicating that infants in both conditions looked significantly longer at the switch event ($M = 8.57$, $SD = 4.78$) than at the familiar event ($M = 5.02$, $SD = 3.36$). There was no significant main effect for condition, $F(1,28) = 1.63$, $p > .20$, nor was there a significant Test Event × Condition interaction, $F(1,30) = 0.96$, $p > .60$. The sex of the infants was also not a significant contributing factor to looking time. Infants' mean looking times for the two conditions are presented in Fig. 4.

The second analysis compared infants' performance on the two noncausal test trials. Looking times were entered into a 2 (Posttest Event: switch vs. familiar) × 2 (Condition: dynamic agent vs. dynamic recipient) × 2 (Sex: male vs. female) mixed-design ANOVA. The analysis indicated that infants' visual fixation to the switch ($M = 7.87$, $SD = 6.12$) and familiar ($M = 8.86$, $SD = 6.32$) events was not reliably different, $F(1,28) = 0.28$, $p > .50$. There was also no significant main effect for condition, $F(1,28) = 0.10$, $p > .60$, and no significant interaction between the variables.

As in the previous experiments, infants' visual fixation to the familiar causal test trial and the first noncausal test trial was examined with a mixed-design ANOVA with trial type (causal vs. noncausal) as the within-subjects factor and condition (dynamic agent vs. dynamic recipient) and sex as the between-subjects factors. The analysis revealed that 14-month-olds looked significantly longer at the noncausal test trial ($M = 9.88$, $SD = 5.96$) than at the causal test trial ($M = 5.02$, $SD = 3.36$), $F(1,28) = 18.41$, $p < .001$. There were no further significant main effects or interactions among the variables.

### Discussion

The rationale for Experiment 3 was to investigate whether 14-month-olds are able to detect and encode relations between an object's part and its causal role and to determine whether they are unconstrained, due to their limited experience in the real world, in the relations they are willing to learn. The results of the experiment showed that 14-month-olds encoded relations that make sense in the real world (when an agent possessed a dynamic part and a recipient possessed a static part) as well as relations that do not make sense in the real world (when an agent possessed a static part and a recipient possessed a dynamic part). This pattern suggests that infants at this age are able to encode such relations, which is consistent with previous work with the same age group (Rakison & Poulin-Dubois, 2002), and have not yet learned that a specific kind of part is associated with a specific causal role. Taken together with the findings of Experiments 1 and 2, this implies that between 14 and 16 months of age, infants are acquiring fundamental information about the parts that are typical of agents and recipients.

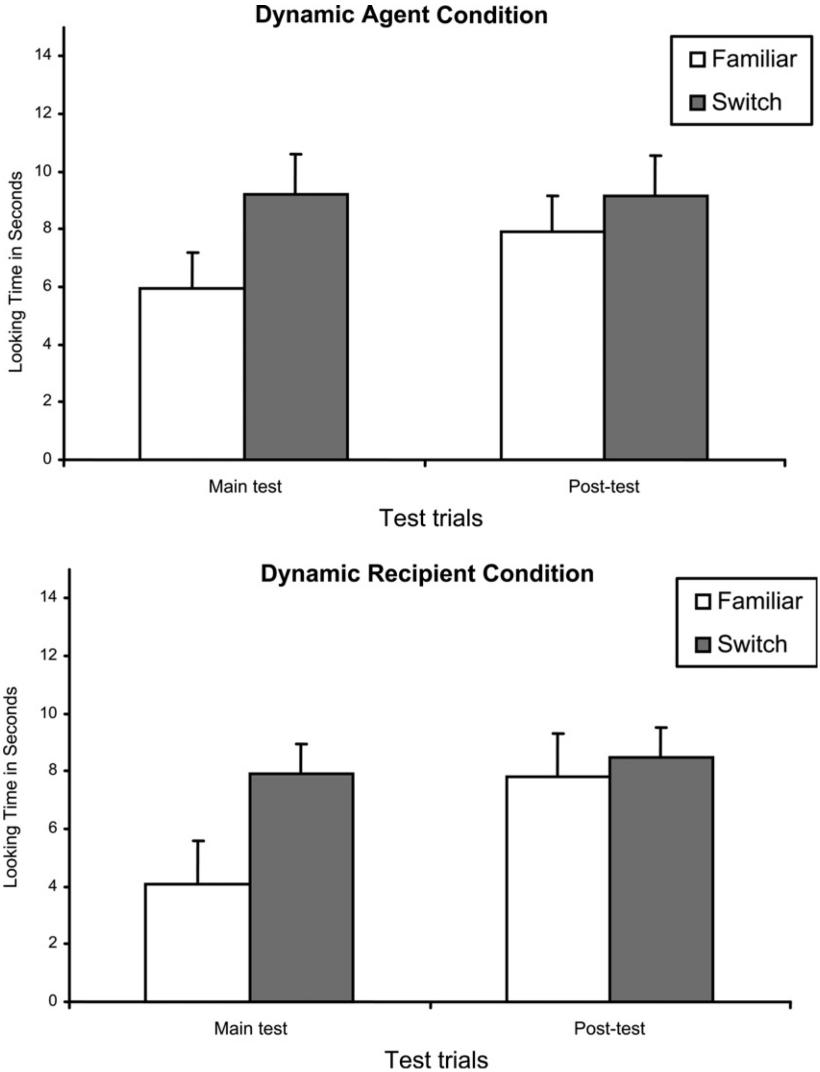


Fig. 4. Mean looking times and standard errors during the two causal and noncausal test trials for 14-month-olds in the dynamic agent and dynamic recipient conditions in Experiment 3.

## Experiment 4

A final issue that needs to be addressed concerns the performance of the 12-month-olds in Experiments 1 and 2. It is possible that the 12-month-olds failed to learn relations between a specific part and the causal role of an object because they were unable to discriminate the two geometric figures presented in the events. There is considerable evidence that infants under 12 months of age perceive as causal the kind of events employed here (e.g., Leslie & Keeble, 1987; Oakes & Cohen, 1990);

however, if infants were unable to discriminate the two figures in the events on the basis of whether they possessed a dynamic or static part, they would be unable to associate distinct causal roles with each one. This issue was addressed in Experiment 4.

## *Method*

### Participants

The participants were 16 healthy full-term 12-month-olds (mean age 12 months 4 days, range = 11 months 22 days to 12 months 10 days). There were 9 boys and 7 girls. Data from 5 additional infants were excluded from the final sample due to a failure to habituate (4) or to fussing or crying (1). Infants were recruited in the same way as in the previous experiments and were given a small gift for their participation.

### Stimuli and design

The stimuli in the fourth experiment were the geometric figures used in Experiments 1, 2, and 3. In contrast to the previous experiments, during the habituation trials a single geometric figure started moving from off the screen and continued to move to the other side of the screen until out of view. Infants were randomly assigned to one of two conditions. In one condition, eight infants were habituated to the figure with the static part moving across the screen. In the other condition, eight infants were habituated to the figure with the dynamic part moving across the screen. In the test trials in both conditions, infants were presented with two events. In the novel event, the figure that moved across the screen possessed a different part (dynamic or static) from that seen during habituation. The familiar event was identical to that seen during habituation. In all events, the stimuli moved from left to right. The events were created with Macromedia Director 8.0 for PCs. Each event lasted 8 s and was repeated three times. The total duration of each event, including the blue screen in between each individual scene, was 30 s.

### Apparatus and procedure

The apparatus and general procedure were identical to those employed in Experiments 1, 2, and 3. Infants were habituated to one event until looking time across three consecutive trials dropped to 50% of that observed across the first three trials. Each event was presented until an infant looked away for more than 1 s or until 30 s had elapsed. The order of the familiar and novel test trials was counterbalanced across infants in each condition.

## *Results*

Infants' looking times were entered into a mixed-design ANOVA with test event (novel vs. familiar) as the within-subjects factor and habituation event (static part vs.

dynamic part) and sex (male vs. female) as the between-subjects factors. The analysis revealed that infants looked significantly longer at the novel event ($M = 8.03$, $SD = 4.47$) than at the familiar event ($M = 4.04$, $SD = 3.07$), $F(1, 12) = 7.14$, $p < .025$. There was no significant main effect for habituation event, $F(1, 12) = 0.72$, $p > .50$, or sex of the participant, $F(1, 12) = 0.01$, $p > .08$. There was also no significant interaction among any of the variables.

### *Discussion*

The results of this experiment show that 12-month-olds could discriminate the two geometric figures used in Experiment 1. These figures were identical except that one possessed a static part and the other possessed a dynamic part. These results suggest that 12-month-olds' failure to associate a specific causal role with a specific part cannot be attributed to a more basic inability to discriminate the figures and parts. Instead, the more credible explanation for the 12-month-olds' behavior in Experiment 1 is that they were unable, given the stimuli presented in the experiments reported here, to associate a specific part of an object with that object's causal role in the event.

## General discussion

A number of theorists have suggested that early concepts for objects include an understanding of their role in a causal event, that is, as an agent or a recipient of an action (Gelman, 1990; Mandler, 1992; Premack, 1990; Rakison & Poulin-Dubois, 2001). Despite the stress laid on identifying which things in the world are agents and which are recipients, little is known about the developmental timetable and trajectory for this knowledge acquisition or the mechanism that underlies it. The four experiments reported here were designed to test whether a sensitive perceptual system, a bias to attend to dynamic cues, and a domain-general associative learning mechanism are sufficient to explain how infants acquire knowledge of the motion properties of animates and inanimates. To address this issue, 12-, 14-, and 16-month-olds were presented with novel geometric figures that engaged in a simple causal event. Experiment 1 revealed that 16-month-olds, but not 12-month-olds, associate a dynamic part with the role of agent and a static part with the role of recipient. Experiment 2 showed that neither 12- nor 16-month-olds associate a static part with the role of agent and a dynamic part with the role of recipient. Experiment 3 indicated that 14-month-olds learn relations between object parts and causal roles that are both consistent and inconsistent with those found in the real world. Experiment 4 demonstrated that 12-month-olds were able to discriminate the two geometric figures in the events.

Taken together, these results suggest that attention to the relation between objects' static and dynamic parts and their causal role is sufficient for infants to learn which things in the world are agents and which things in the world are recipients. That is, the experiments show that infants in the second year of life are sensitive to the relation between the causal role that an object plays in an event and the static or dynamic parts that it possesses. The geometric figures presented to infants in the experiments were designed to be identical in every way except for whether they possessed a static or dynamic cue, and there was no other basis on which to learn the identity of the objects in each causal role. That infants were able to learn the identity of the agent and recipient is perhaps even more impressive given the similarity of the two objects. In the real world, things that tend to act as agents (e.g., people, animals, insects) and things that tend to act as recipients (e.g., furniture, tools, plants) are relatively perceptually distinct in terms of their shapes and parts. If infants in the habituation procedure are able to learn rapidly that two perceptually similar objects with either dynamic or static parts play different roles in a causal event, it is plausible that in the real world infants are able to learn such relations for diverse objects and entities.

The current data also depict the developmental trajectory of infants' knowledge acquisition of the identity of agents and recipients. Infants at 12 months of age did not learn the identity of agents and recipients, at least for artificial objects of the kind used here, on the basis of relations between those objects' causal role and their parts. Infants at 14 months of age encoded part–causal role relations but were unconstrained in those that they encoded. In contrast, infants at 16 months of age encoded only those relations that make sense in the real world. This suggests a developmental course whereby infants initially are not sensitive to, or are unable to encode, certain correlations between dynamic and static cues, after which they to encode all correlations to which they are exposed and finally encode only those correlations that are consistent with their prior experience. It remains to be seen, however, at which age infants pass through this developmental transition. I do not suggest that in the real world infants at the specific ages tested here (12, 14, and 16 months) are necessarily processing relations between dynamic cues and causal roles in the way that is portrayed by these experiments. For example, if the geometric figures in the current experiments were more distinct, if the parts of the objects were more ecologically valid, or if the dynamic and static parts were more salient, 12-month-olds might have been able to learn the identity of the agents and recipients. There is evidence, for example, that infants are able to attend to and encode relations between dynamic cues under certain conditions. Infants are sensitive to dynamic relations in studies that involve conditioning, such as when 3-month-olds learn to kick their leg to make a mobile move (Hayne, 1996), or in the presence of a facilitating cue such as, in the case of sound and object relations, temporal synchrony, intensity shift, or common rhythm (Gogate & Bahrick, 1998). There is also impressive evidence that infants are sensitive to point–light displays for animals and vehicles (Arterberry & Bornstein, 2002), although these findings can be explained by perceptual categorization of circular versus pendulum motion rather than by the ability to encode correlations among dynamic cues.

Based on the findings of the current experiments, I suggest that the developmental pattern observed across the experiments is in all likelihood similar to that involved when infants learn about the identity of agents and recipients in the real world; however, the exact age at which this pattern begins and ends is as yet not known. As a caveat to this statement, it is worth noting that the data reported here suggest that by 16 months of age, infants' learning is constrained as a result of real-world experience with exemplars that exhibit the appropriate part–causal role relations. The developmental transition reported here, therefore, must be in place by that age, although it is quite plausible that such constrained learning is in position earlier in development. It is also worth noting that the different age groups' performance in the current experiments may indeed reflect when they learn about the identity of agents and recipients. That is, similar studies on infants' ability to learn about relations about local and global dynamic cues involved in motion properties have shown that it is not until 14 months of age or so that they are able to encode such relations (Rakison & Poulin-Dubois, 2002). One possibility, therefore, is that prior to approximately 12 or 14 months of age, infants might be unable to encode relations among dynamic cues that involve relatively complex information related to motion characteristics of objects and entities. One explanation for this pattern is that infants before 12 to 14 months of age might simply not possess the requisite attentional and information processing abilities to encode relations between local and global dynamic cues in a causal context (Oakes & Madole, 2003).

At first consideration, the finding that 14-month-olds attend to and encode a larger amount of information than do 16-month-olds initially might seem counterintuitive. It is more typical in research on perceptual and cognitive development for researchers to find that older infants' learning capacity outreaches that of younger infants. However, similar trends have been reported recently in a number of other studies with infants. Madole and Cohen (1995), for example, showed that 14-month-olds will learn form–function relations that do and do not make sense in the real world (e.g., even when the form of one part predicts the function of another part), whereas 18-month-olds will learn only relations that are consistent with those they have experienced. Similarly, Namy, Campbell, and Tomasello (2004) found that 18-month-olds will learn both arbitrary and iconic gestures, whereas 24-month-olds will learn only iconic ones, and Stager and Werker (1997) showed that 8-month-olds can make more fine-grained syllable discriminations than can 14-month-olds, presumably because the former have less experience with the syllables of their native lexicon. Taken together, this literature suggests a common rapid developmental transition in infants' attention to, and eventual restriction of, statistical regularities.

I suggest that this pattern indicates that the same domain-general mechanism is responsible for learning across a range of domains (e.g., language, gesture, animacy) and that through experience this mechanism becomes constrained in the information that it will encode. How might such a process operate? In this regard, I adopt a constrained attentional learning perspective similar to that of Smith et al. (1996). They argued that naming automatically directs children's attention to certain object properties (e.g., shape) due to the associations they have learned. Similarly, I suggest that as infants experience consistent feature–feature correlations in the world (e.g., that agents possess dynamic features), the represented associative link between those features becomes strengthened. This strong associative link then serves automatically to guide, or constrain, infants' attention toward such relations to the exclusion of other ones. Initially, these overlearned associations and the attentional constraints that follow from them cannot be inhibited, and this explains why 16-month-olds in Experiment 2 did not learn the relations that were incompatible with those found in the real world. Over developmental time, however, the mechanism may become less automatic as young children develop more conscious control over the aspects of the array to which they attend (as adults, we are aware that recipients of actions can possess dynamic parts). One assumption of this model is that the same constrained attention mechanism underlies learning for all aspects of object motion; consequently, one prediction is that the same trajectory occurs across an even wider range of developmental phenomena. In support of this view, recent work from my laboratory has revealed that infants undergo the same developmental trajectory later in the second year of life when they learn about the identity of self-propelled objects (Rakison, 2005).

On a related issue, the findings presented here can be interpreted as support for the enrichment view of representational development (Eimas, 1994; Jones & Smith, 1993; Quinn & Eimas, 1997, 2000; Rakison, 2003, 2004, in press; Rakison & Poulin-Dubois, 2001, 2002). The experiments show that the relation between a motion property and a single dynamic or static part is sufficient for infants to learn the identity of agents and recipients in a causal event. As such, they reveal that associative processes are adequate for infants to learn about the identity of objects that engage in distinct conceptual roles. That infants were able to do so under relatively stringent conditions—because the objects were virtually identical—and in a relatively short time span is perhaps even more impressive. Based on these findings and other recent research (e.g., Rakison, 2004, in press), I have proposed that infants' ability to detect and encode dynamic as well as static part correlations leads to a representation of an associative link that allows expectations about one component of the link based on the perception of the other component (Rakison, 2003, in press; Rakison & Hahn, 2004). If, for example, infants learn that things with wings fly, they will expect flying things to have wings and things that have wings to fly. In some cases these expectations will be incorrect (some things that fly do not have wings, e.g., helicopters), but in general they will allow for accurate inferences about the properties of things. Similarly, it is suggested here that infants in the second year of life, or perhaps earlier, may start to expect that things with dynamic parts are agents and that things that act as agents possess dynamic parts.

To summarize, the four experiments reported here show that attention to the relation between an object's causal role and its dynamic or static part can account for how infants represent the identity of agents and recipients. Infants at 12 months of age did not encode the relation between an object's causal role and its parts, whereas infants at 14 months of age encoded such relations but were unconstrained in those they learned. Infants at 16 months of age encoded only those relations that make sense in the real world such as when an agent possessed a dynamic part. Based on these findings and previous research (e.g., Madole & Cohen, 1995; Stager & Werker, 1997), it is suggested that infants' experience with statistical regularities in the real world constrains the information that will be encoded in the future. Furthermore, it is argued that a sensitive perceptual system coupled with a domain-general associative learning mechanism (Quinn & Eimas, 1997, 2000; Rakison, 2003) is sufficient to explain how knowledge about the identity of agents as recipients, as well as knowledge about other motion properties related to the animate–inanimate distinction, is acquired.

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