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Understanding the actions of others depends on the insight that these actions are structured by intentional relations. In a number of conceptual domains, comparison with familiar instances has been shown to support children's and adults' ability to discern the relational structure of novel instances. Recent evidence suggests that this process supports infants' analysis of others' goal-directed actions (Gerson & Woodward, 2012). The current studies evaluated whether labeling, which has been shown to support relational learning in other domains, also supports infants' sensitivity to the goal structure of others' actions. Ten-month-old infants observed events in which a familiar action, grasping, was aligned (simultaneously presented) with a novel tool-use action, and both actions were accompanied by a matched label. Following this training, infants responded systematically to the goal structure of the tool-use actions in a goal imitation paradigm. In control conditions, when the aligned actions were accompanied by nonword vocalizations, or when labeling occurred without aligned actions, infants did not respond systematically to the tool-use action. These findings indicate that labels supported infants' comparison of the aligned actions, and this comparison facilitated their understanding of the novel action as goal-directed.

Across a variety of conceptual domains, knowledge about relations between entities is as important as knowledge about the entities themselves. In the domains of mathematical, spatial, and causal reasoning, for example, understanding ''greater than five,'' ''under the table,'' and ''push button to turn on light'' require representing relations between numbers, objects, and action-outcomes, respectively. Indeed, it has been argued that relational structure is essential in many cognitive domains about which children learn early in life (Gentner, 1988, 2003; Gentner & Medina, 1998; Waxman & Leddon, 2011).

Relations are also integral to the domain of social cognition. In particular, when we view someone carrying out an intentional action, we interpret the movement in terms of the relation between the agent and his or her goal rather than focusing on the physical motion of the agent's body through space. Barresi and Moore (1996) noted that this tendency to represent others' actions in terms of *intentional relations* is pervasive in mature social cognition and is foundational for social interaction and social learning. Recent research has shown that the origins of this social worldview can be traced to very early in development. By 6 months, if not before,

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infants represent others' actions as structured by the relation between agent and goal (see Woodward, Sommerville, Gerson, Henderson, & Buresh, 2009, for a review). In habituation experiments, infants show a strong novelty response to test events that change the goal of an action compared with events that change movement patterns while preserving the goal (e.g., Woodward, 1998); in imitation experiments, infants selectively act on the goals of others' prior actions (e.g., Gerson & Woodward, 2012; Hamlin, Hallinan, & Woodward, 2008; Mahajan & Woodward, 2009); and in eye-tracking experiments, infants generate predictions about a person's next actions based on her prior goals (e.g., Cannon & Woodward, 2012).

How do infants gain insight into the intentional structure of others' actions? A number of factors have been shown to support infants' propensity to view actions as structured by intentional relations, including prior experience producing the action (e.g., Sommerville, Woodward, & Needham, 2005) and the presence of behavioral cues (e.g., rational patterns of movement or multiple, equifinal attempts to reach a goal; Biro & Leslie, 2007; Gergely & Csibra, 2003; Luo & Johnson, 2009). We consider another factor, gleaned from the broad literature on relational learning and conceptual development. We hypothesize that the domain-general ability to form implicit structural analogies between familiar and novel instances supports infants' understanding of novel actions as intentional. More specifically, we propose that familiar actions (i.e., actions infants can already produce and recognize as intentional) can be compared to novel actions (i.e., actions infants cannot yet produce or recognize as intentional) through the physical alignment (i.e., simultaneous copresence) of the two actions.

In research with children and adults, analogical learning has been shown to support insights about relational structure in spatial tasks (e.g., Casasola, Bhagwat, & Burke, 2009; Loewenstein & Gentner, 2001), verb learning (e.g., Childers, 2008, 2011), categorization (e.g., Graham, Namy, Gentner, & Meagher, 2010; Namy & Gentner, 2002; Oakes, Kovak-Lesh, & Horst, 2009), and problem solving (e.g., Kurtz & Loewenstein, 2007), among other domains. These collective findings indicate that comparing two exemplars facilitates reasoning about the structural similarities between them and supports insights about the relational structure of a novel exemplar. For example, 3-year-old children who have the opportunity to simultaneously compare the spatial relations in two model rooms are better able to extract the relational information (e.g., a hiding place defined by spatial relations) and apply this to a new room (i.e., find a toy hidden in the same spatial location) compared with children who do not have the opportunity to compare multiple models. Several researchers have hypothesized that comparison between self and other may contribute to infants' growing understanding of others' intentional actions—for example, in allowing infants to understand others' actions on analogy with their own actions (e.g., Barresi & Moore, 1996; Gerson & Woodward, 2010; Meltzoff, 2005; Tomasello & Moll, 2007)—but until recently, there was little direct evidence evaluating this hypothesis.

A recent study (Gerson & Woodward, 2012) tested this hypothesis directly by examining whether comparison of a novel action to the infants' own (familiar) actions would enable infants to understand the novel action as intentional. Seven- and 10-month-old infants typically recognize grasps as goal-directed actions but do not yet interpret tool-use actions as such (e.g., Cannon & Woodward, 2012; Sommerville, Hildebrand, & Crane, 2008; Woodward, 1998). In Gerson and Woodward's (2012) study, infants of these ages were given the opportunity to align and compare the goal of their grasping actions with the experimenter's tool-use actions during a game in which the experimenter handed the infant a series of toys using a mechanical claw. The experimenter's grasp of each object with the tool began before the infant's reach began and typically continued until the infant grasped each object with his or her hand. This allowed the goal of these two actions (grasp with tool and grasp with hand) to be physically copresent and compared.

Infants were then tested in a *goal imitation* paradigm that assessed their tendency to reproduce the goal-relevant aspects of the experimenter's tool-use actions. In this procedure, infants viewed the experimenter as she grasped one of two toys using the tool. Then infants were given the opportunity to choose between the two toys. Prior research using this method has shown that when infants see an action they recognize as goal-directed, they subsequently select the toy that was the experimenter's goal. In contrast, when the modeled actions are not understood as goal-directed, infants choose randomly between the two toys (Hamlin et al., 2008; Mahajan & Woodward, 2009). Thus, infants' responses in this paradigm reflect their analysis of the modeled action as goal-directed. In the Gerson and Woodward (2012) studies, infants who had undergone the critical alignment manipulation responded to the tool-use actions as goal-directed, systematically choosing the object that had been the goal of the experimenter's tool actions. In control conditions, infants who had interacted with the tool without a toy in its grasp or who had viewed the tool's functional properties (i.e., seeing the experimenter use it to transport toys) without simultaneously acting on the toy themselves subsequently chose randomly in the goal imitation paradigm. Thus, the alignment and comparison between the goal of the tool actions and of infants' own actions seemed critical to supporting infants' understanding that the tool-use action was goal-directed.

These findings support a novel, and heretofore undocumented, conclusion: Analogical learning mechanisms permit young infants to glean relational, conceptual representations of others' intentional actions. This is a strong conclusion, and if it is right, then additional markers of analogical learning should be evident in infants' learning about novel actions. In the current study, we pursued this question by testing whether providing labels facilitated infants' comparison of familiar and novel actions. Gentner and colleagues (e.g., Ratterman & Gentner, 1998) have proposed that language supports relational learning because it invites an individual to seek likeness between two labeled exemplars.

The link between conceptual learning and language has been well documented in young children and infants, particularly in the context of object categorization. Hearing the same label for a series of objects leads infants and children to categorize these objects. This effect seems to depend on each exemplar being linked with the same name: Linking object with tones or nonlabeling speech, such as vocal expressions of interest (e.g., Fulkerson & Waxman, 2007; Namy & Waxman, 2000), or linking each object with a different name (e.g., Waxman & Braun, 2005), does not provide the same benefit (see also Ferry, Hespos, & Waxman, 2010; Waxman & Markow, 1995; see Waxman & Leddon, 2011, for a review). The labels given to the exemplars, however, need not be familiar words. English nouns (e.g., ''car,'' ''plane,'' and ''pig''; Balaban & Waxman, 1997; Waxman & Markow, 1995), novel, nonsense words (e.g., ''toma,'' ''wug,'' and ''blicket''; Ferry et al., 2010; Waxman & Braun, 2005; Waxman & Markow, 1995), and content-filtered words (unrecognizable by adults; e.g., Balaban & Waxman, 1997) all play similar roles in object categorization tasks. Thus, the use of common labels across multiple exemplars promotes comparison among exemplars. These effects have been found in infants as young as 4 and 6 months of age (Ferry et al., 2010; Fulkerson & Waxman, 2007).

Beyond promoting comparison in general, language can support analogical learning by highlighting the specific relational similarities between two exemplars. To illustrate, Loewenstein and Gentner (2005) introduced young children to search problems in which they needed to use information provided using one three-tiered shelf to find an item hidden in the analogous location in a second three-tiered shelf. When the experimenter labeled the location with a term that specified its relation to the other locations (e.g., ‘‘bottom,’’ ‘‘middle,’’ or ‘‘top’’), children more readily used the common structure of the two shelves to find the hidden object compared with when no labels were provided. Interestingly, both relational words (e.g., in, on, under; Loewenstein & Gentner, 2005; Rattermann & Gentner, 1998) and novel, nonsense words (e.g., dax; Christie & Gentner, 2010; Gentner, Anggoro, & Klibanoff, 2011; Kotovsky & Gentner, 1996; Pruden & Hirsh-Pasek, 2006) similarly benefit comparison and relational extraction. For example, after children were told that a knife was a ‘‘dax’’ for a watermelon, they were asked what the ‘‘dax’’ for paper was and were given the options of a stack of papers, a pencil, or scissors (Gentner et al., 2011). Hearing the relational label helped 4-, 5-, and 6-year-old children choose the correct relational answer—the scissors. Labels have been shown to be particularly helpful in highlighting relational similarity when used in the context of two exemplars presented side by side (see Christie & Gentner, 2010; Gentner et al., 2011).

In the current work, we tested whether labels support infants’ ability to discern the relational structure of a novel action under conditions in which comparison is challenging for infants. In Gerson and Woodward’s (2012) study, alignment of familiar and novel actions helped infants discern the goal structure of the novel (tool-use) action, but only when the familiar action was produced by the infant. Infants who observed two experimenters demonstrate aligned reaching and tool actions (one experimenter passed toys to the other using the tool) did not subsequently respond systematically to tool-use actions in test trials. This finding suggests that more support was needed to facilitate infants’ comparison of the familiar and novel actions when they themselves were not involved in the interaction.

Our goal in the current study was to provide labels that could support infants’ detection of the relational similarity between the familiar (grasping) and novel (tool-use) actions in this situation. Based on findings with older children, we hypothesized that labels would be most effective when they were provided with each of the two actions as they occurred side by side. Because our events involved intentional actions, it seemed most natural to have the labels be uttered by the two experimenters. Accordingly, we had each of the experimenters, one at a time, utter the same name for the goal object as the actions played out. By having each experimenter utter the label as she reached for the toy (‘‘An X, here, an X,’’ ‘‘An X, thanks, an X’’), we provided a relational context for the noun in much the way that a locution like ‘‘the dax for the paper’’ (Gentner et al., 2011) did so for older children.

Research with older children has shown that several classes of words, including prepositions (Loewenstein & Gentner, 2005), verbs (Gentner, Simms, & Flusberg, 2009), and nouns (Christie & Gentner, 2010; Gentner et al., 2011), can highlight relational similarities. Because, to date, the only effects of words on conceptual learning in infants younger than than 12 months of age have involved nouns, we decided to use nouns in the current study. However, unlike prior studies with infants, our aim was not to promote categorization of the objects involved in the events, but rather to highlight the similarity between the reaching and tool actions as they occurred directed at the same object. Therefore, we chose not to use the same noun across all of the objects, but instead to use a different noun for each object as it was passed between the experimenters. That is, infants viewed the experimenters simultaneously performing familiar (grasp) and novel (tool-use) actions on the same goal object and using the same label for the object as they did so. This scenario was repeated for each of 12 toys.

To evaluate whether linguistic labels play a unique role in supporting comparison or whether a common sound associated with each object (vocalized by both experimenters) would similarly influence infants' responses, a second group of infants was tested in the *nonword vocalization condition*. In this condition, infants heard both experimenters express matched nonword vocalizations for each toy. The vocalizations (''oohs'') were not words and were not framed with an indefinite article (as the labels were) and thus should not serve as conceptual markers. Nonword vocalizations and other nonword sounds do not have the same effect as linguistic labels on infants' categorization responses, suggesting that words provide specific support for comparison and cognitive learning in infants (e.g., Ferry et al., 2010; Fulkerson & Waxman, 2007; Mackenzie, Graham, & Curtin, 2011; Namy & Gentner, 2002). These nonword vocalizations, although void of conceptual or linguistic cues, could serve as referential cues in that both experimenters gazed toward and expressed interest in the object being passed. Thus, we specifically tested whether linguistic markers, rather than referential cueing, facilitated comparison of the hand and tool grasping actions. If the labels do serve as conceptual markers, an important question concerns whether the labels are beneficial on their own or only when spoken in conjunction with the observation of physical alignment. First, hearing labels applied to the claw events could help infants identify the relational structure of the event without the need for comparison with a familiar action. Second, hearing the toys labeled during test trials could lead infants to reach for the labeled toy. We evaluated both of these possibilities in a nonalignment labeling condition, in which infants heard the labels for the objects without viewing physical alignment during the claw familiarization. To summarize, in the labeling and nonword vocalization conditions, infants saw two experimenters engage in a toy-passing game in which one experimenter used a tool to give toys to the other experimenter, who took each toy with her hand (see Figure 1A). This allowed infants to observe a familiar and novel action physically aligned. During the passing of each toy, in the *labeling condition*, the experimenters each used the same label for the toy during passing. In the *nonword vocalization condition*, infants heard each experimenter utter a positive vocalization as she acted on the toy. In a third condition, nonalignment labeling, infants saw one experimenter move each of the toys in a similar movement to that in the other conditions as she labeled each toy, but her action was not simultaneously presented with another individual's. Following these demonstrations, we assessed infants' tendency to selectively imitate the goal object chosen in a tool-use action (see Figure 1C). If labels provide a unique benefit

(A) (B) (C)

FIGURE 1 Claw familiarization trials (A), test trial demonstrations (B), and toy choice (C) were all *visually* identical in both conditions. Only the sounds vocalized during the actions differed.

for comparison, it was predicted that infants in the labeling condition would subsequently imitate the goal of the tool-use action, but those in the nonword vocalization condition and nonalignment labeling condition would not do so.

METHOD

Participants

Sixty 10-month-old infants (9.5–10.5 months) participated in one of three conditions: *labeling* ($n = 20$; 10 males; $M_{age} = 9.9$ months), *nonword vocalization* ($n = 20$; 9 males; $M_{age} = 9.9$ months), or *nonalignment labeling* ($n = 20$; 11 males; $M_{age} = 9.9$ months). Because labeling was in English, all infants heard English at least 75% of the time in their daily lives (as confirmed by parents). Infants were recruited from the Washington, DC, metropolitan area through mailings and advertisements. An additional 8 infants in the labeling condition, 9 infants in the nonword vocalization condition, and 1 infant in the nonalignment labeling condition started the study but were not included in analyses due to side preference during the test phase (choosing the object on the same side on all trials, see the Procedure section). Based on parental report, the sample of infants was 48% Caucasian, 27% African American, 10% Multiracial, 8% Asian, 5% Hispanic, and 2% Unreported.

Procedure

During the familiarization phase, all infants were introduced to each of the 12 toys (see Figure 2) used during the experiment and to the claw. During toy familiarization, the experimenter presented each toy one at a time in randomized order on alternating sides of a 76-cm × 23-cm tray, allowing the child to grasp and explore the toy. Next, in the labeling and nonword vocalization conditions, the claw familiarization phase commenced, during which a second experimenter (E2) appeared to the first experimenter's (E1's) right, and the demonstration of the claw actions began. E1 passed each toy to E2 (in random order) using a claw (see Figure 1A; all 12 toys were passed). In the *labeling condition*, the two experimenters used the *same* basic level name for each object: E1 said, for example, ''A turtle, here, a turtle,'' as she offered the toy, and E2 then said, ''A turtle. Thanks. A turtle,'' as she took the toy. In the *nonword vocalization* condition, E1 said, ''Ooh, here, ooh,'' as she passed each toy, and E2 said, ''Ooh, thanks, ooh,'' as she received it. ''Ooh'' was chosen as a nonlinguistic vocalization that indicates positive affect. If the infant was not attending, E1 tapped near the toy or said ''look'' to the infant. In this way, it was ensured the infant observed the physical alignment of E1's grasp for the toy with the tool and E2's grasp for the toy with her hand during vocalizations. In the nonalignment labeling condition, only one experimenter was present during the claw familiarization phase. The experimenter used the claw to move each toy across the table and labeled each toy four times as she did so (e.g., ''A turtle, here, a turtle. A turtle, it's a turtle''; claw familiarization). Thus, infants in this condition observed claw actions on each toy while hearing the toy labeled an equal number of times as in the labeling condition.

After claw familiarization, infants in all three conditions underwent visually matched test trials. Infants saw a pair of toys, 28 cm apart, on the tray, placed in front of E1. After ensuring

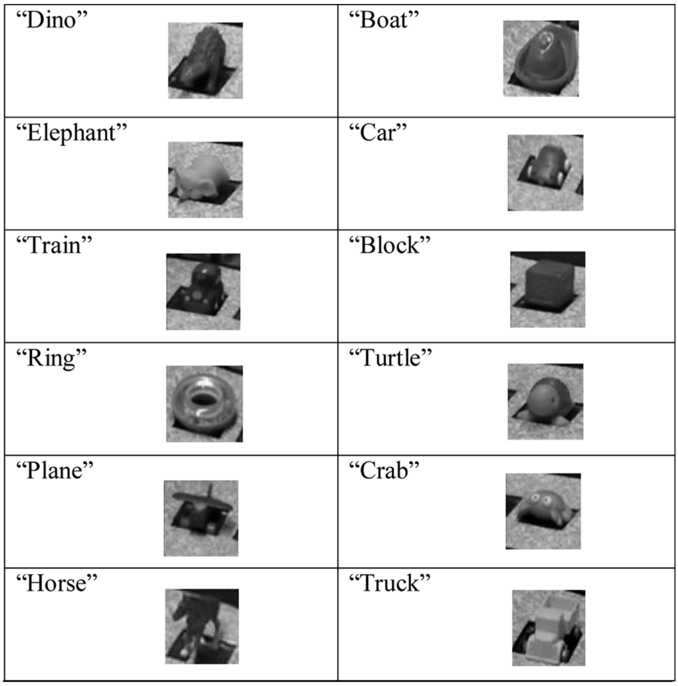

FIGURE 2 Pairs of toys infants viewed and the labels with which each toy was named.

the infant saw both toys, the experimenter made eye contact with the infant and said, ''Hi! Look!'' As she said ''look,'' she shifted her gaze toward the target toy. She then reached contralaterally and grasped the toy using the claw but did not pick up or move the toy (see Figure 1B). The experimenter gazed at the toy throughout the grasp and either labeled the toy (e.g., ''A turtle, ooh, a turtle'') or said ''Oooh!'' twice as she reached (in the labeling and nonalignment labeling and the nonword vocalization conditions, respectively). She then withdrew the claw, placed it on her lap, and again established eye contact with the infant. She then said ''Hi!'' and pushed the tray to the infant's side of the table, and then said, ''Now it's your turn!'' She then looked down until the infant had chosen a toy from the tray. If the infant did not choose a toy after approximately 30 s, the experimenter removed the tray.

This procedure was repeated for six trials with a new pair of toys presented for each trial. Each pair consisted of 2 toys from the set of 12 toys to which infants were previously familiarized (in line with previous studies using this paradigm, e.g., Gerson & Woodward, 2012; Hamlin et al., 2008; Mahajan & Woodward, 2009). The experimenter alternated reaching to her left or right. Between infants (within each condition), each of the toys in a pair was the experimenter's goal 50% of the time, and side of placement of each toy and side of first reach were counterbalanced. The order of the pairs was randomized for each infant. After testing, parents were asked to fill out the Level 1 MacArthur Bates Communicative Development Inventory Short Form (MCDI; Fenson et al., 2000) to assess infants' vocabulary. Infants' responses were coded offline from video in two passes using a digital video coding program (Mangold, 2010). Coders were unaware of the condition to which the infant was assigned and to the hypotheses of the studies. They coded the claw familiarization and test periods separately, without sound so that they were not able to hear whether labeling was occurring. Because the video of the infant was shot from behind the experimenters, coders were not able to see visual cues that might have indicated whether words were being spoken. In one pass, the coders scored infants' toy choice on each trial. During this coding, they could not see the demonstration event and did not know which toy was the goal. The infant's choice was coded as the 1st toy she touched as long as the touch was preceded by visual contact. If the infant touched a toy without looking at it first, and this subsequently drew the infant's attention to the toy, this was coded as a mistrial. If an infant chose the toy on one side of the mat on all six trials, he or she was not included due to side preference (see ''Participants'' section). A second coder scored all subjects' toy choices for reliability, Cohen's $\kappa = .91$. In a second pass, coders measured infants' attention to the claw, toys, and experimenter during both test trials and claw familiarization. A second coder assessed attention for 25% of infants. Judgments were strongly correlated during both test trials (rs > .95) and claw familiarization (rs > .90). The second coder also coded attention for 25% of the infants, and the two coders' judgments of attention to each location were strongly correlated (rs > .96).

RESULTS

The main analyses evaluated whether infants in the labeling, nonword vocalization, and nonalignment labeling conditions differed from each other and from chance in their imitation of the experimenter's goals. On average, infants produced codeable responses on an average of 5.7, 5.8, and 5.5 out of the 6 test trials in the labeling condition, nonword vocalization condition, and nonalignment labeling condition, respectively. All infants produced at least 4 codeable test trials. An omnibus analysis of variance with the proportion of codeable test trials on which infants imitated toy choice as the dependent variable, condition as the between-subjects factor, sex as a within-subjects factor, and MCDI score and age as covariates revealed a main effect of condition, $F(1, 59) = 4.31$, $p = .019$, partial $\eta_p^2 = .14$, and no other main effects or interactions, ps > .15, partial η_p^2s < .07.

Planned pairwise comparisons (all one-tailed) revealed that infants in the labeling condition differed in their goal imitation from infants in both the nonword vocalization condition, *mean difference* (*md*) = .19, $p = .003$, and the nonalignment labeling condition, $md = .12$, $p = .030$. Infants in the nonword vocalization and nonalignment labeling conditions did not differ from one another, $md = .064$, $p = .16$ (see Figure 3). Further planned contrasts were conducted to evaluate whether infants selected the experimenter's goal object at rates greater than chance (50%). Infants in the labeling condition systematically imitated the experimenter's goal at above-chance rates,[1] $t(19) = 2.62$, $p = .0085$, Cohen's $d = 1.20$, whereas infants in the nonword vocalization, $t(19) = -1.35$, $p = .096$, Cohen's $d = 0.62$, and nonalignment labeling, $t(19) = 0.011$, $p = .50$, Cohen's $d = 0.005$, conditions did not differ from chance in goal imitation.

[1]When infants removed from final analyses due to side bias are included, results reflect the same pattern, $t(26) = 2.22$, $p = .017$.

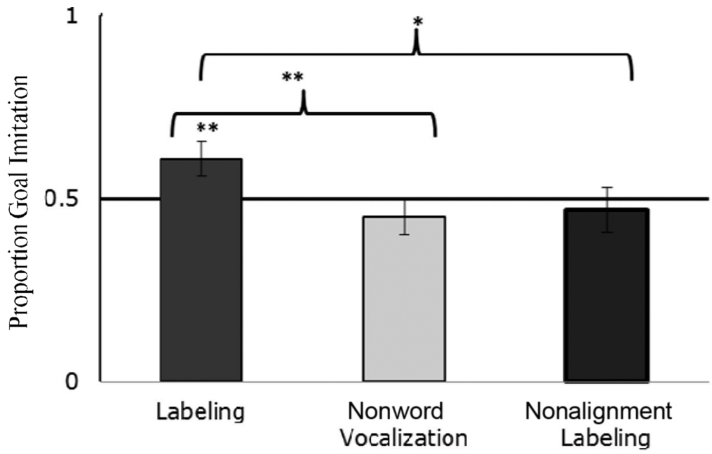

FIGURE 3 Proportion of test trials during which infants imitated the experimenter's toy choice (error bars are standard errors). The black line represents chance level of imitation (50%). $^{*}p < .05$. $^{**}p < .005$.

Individual patterns of response revealed similar patterns to those revealed in the main analyses. In the labeling condition, 12 infants chose the goal object on more than 50% of the trials, 3 were at chance, and 5 chose the goal on fewer than 50% of trials, $p = .072$, by sign test. In the nonword vocalization condition, 6 infants chose the goal object on more than 50% of trials, 3 were at chance, and 11 chose the goal on fewer than 50% of trials. In the nonalignment labeling condition, 8 infants chose the goal object on more than 50% of trials, 3 were at chance, and 9 infants chose the goal on fewer than 50% of trials. The Kruskal Wallis Test provided nonparametric support for the above-reported findings that infants in the three conditions differed from one another in their imitation rates, $\chi^2(2) = 7.50$, $p = .024$.

As in previous studies using this paradigm (Gerson & Woodward, 2012; Hamlin et al., 2008; Mahajan & Woodward, 2009), secondary analyses were conducted to evaluate whether infants' differential responses on test trials could have been influenced by differential affects of the manipulations on their attention to the events during test trials or during claw familiarization. During test demonstrations, infants in the different conditions did not differ in their relative attention to the goal toy versus nongoal toy, $F(2, 57) = 1.34$, $p = .27$, or in their attention to the experimenter, $F(2, 57) = 1.59$, $p = .21$. Infants in all three conditions attended significantly more to the experimenters' goal than to her nongoal during test trial demonstrations, $t(19) = 7.12$, $p < .001$, Cohen's $d = 2.61$; $t(19) = 8.88$, $p < .001$, Cohen's $d = 2.16$; and $t(19) = 7.43$, $p < .001$, Cohen's $d = 1.96$ (see Figure 4). Infants' relative attention to the goal object during the test demonstration was not significantly correlated with their tendency to choose the goal object in any condition, $ps > .58$. Further, infants in the three conditions did not differ in the proportion of time they attended to the experimenter(s) and the movement event during the claw familiarization, $p = .18$. Neither attention to the experimenter nor the event was correlated with infants' subsequent tendency to select the goal object in any condition, $ps > .31$. Thus, we found no evidence that infants' responses during test trials were a function of attentional differences during test trial demonstrations or claw familiarization.

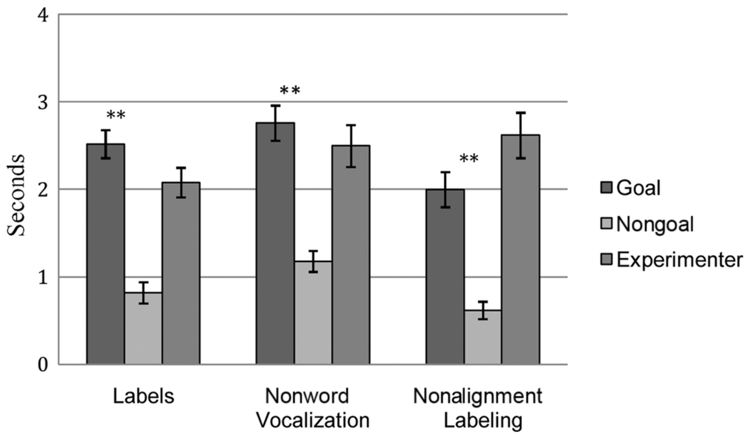

FIGURE 4 Infants' attention to the different aspects of the test trial demonstrations in Study 1 (**$ps < .001$).

DISCUSSION

When 10-month-old infants viewed a novel action, the use of a tool, aligned with a familiar action, grasping, and heard the goals of these actions labeled, they subsequently responded systematically to the goal structure of the novel action. When the aligned actions were accompanied by nonword vocalizations, or when labeling occurred without aligned actions, infants did not respond systematically to the tool-use action on test trials. Infants' attention to the objects and actors in the scenes was not correlated with their responses in the goal imitation procedure across these conditions. Therefore, we found no evidence that infants' differential responding on test trials resulted from differences in the way the events entrained their attention. Instead, the findings indicate that labels supported infants' comparison of the aligned actions, and this comparison facilitated their understanding of the novel action as goal-directed. These findings are consistent with previous research demonstrating that labels serve to uniquely highlight important commonalities to infants (e.g., Fulkerson & Waxman, 2007) and that language can highlight specific relational similarities for children (e.g., Christie & Gentner, 2010; Loewenstein & Gentner, 2005). Labels alone did not support relational analysis, and hearing labels during the test phase did not lead infants to select the labeled object. Infants in the nonalignment labeling condition heard the labels the same number of times in conjunction with claw actions during both familiarization and test, and with the same toys as infants in the labeling condition. Thus, the presence of labels in the absence of aligned exemplars seemed not to support infants' understanding of the claw events as goal-directed.

The familiarization events in the nonalignment labeling condition differed from those in the labeling and nonword vocalization conditions in that they involved one experimenter, rather than two. This was necessitated by the goal of evaluating the effects of labeling in the absence of the aligned actions of two actors. This difference in the number of experimenters could not have driven differences in the findings across the two studies. First, the proportion of familiarization trials infants spent attending to the experimenter(s) versus the toy movement did not differ between conditions. Second, the proportion of time infants attended to the goal versus nongoal toy during test trials across conditions and infants did not differ in the time they spent attending to the experimenter during test trial demonstrations. Third, previous findings indicate that infants' goal imitation is unrelated to the number of experimenters present during familiarization trials. That is, in a previous series of studies (Gerson & Woodward, 2012), infants imitated an experimenter's goal choice when there was only one experimenter present if the infant aligned his or her actions with the experimenter's tool-use actions (but not if there was no alignment). Infants did not, however, imitate the experimenter's toy choice if they had seen two experimenters align their actions without labeling the actions (much like the nonword vocalization condition). Given these inconsistencies in findings concerning the number of experimenters present, it is unlikely that the presence or absence of an experimenter during familiarization trials makes a great difference. Instead, the pertinent issue concerns whether actions between experimenters (or between the child and one experimenter) are physically aligned. Thus, we conclude that it was the conjunction of labeling and the presence of aligned familiar and novel actions that support infants' goal imitation in the current studies.

Across all three conditions, several movement and referential cues provided information about the observed actions. In the labeling and nonword vocalization condition, infants saw the same exact visual cues; thus, the movement cues present were precisely matched. In these conditions, they observed referential cues in that both actors made eye contact with the object they were grasping, with the other experimenter, and with the infant. In both of these conditions, the child also heard both experimenters remark about the object being passed. In the nonalignment labeling condition, infants observed similar movement cues in that they saw the experimenter move each toy with the claw (thus demonstrating the claw's functional capacity). They also saw the experimenter gaze toward the toy and shift gaze between the infant and the toy. Finally, they heard the experimenter label the toy for an equivalent number of times as in the labeling condition. Thus, across conditions, the movement and referential cues provided were matched. The critical difference between these conditions was the conjunction of conceptual markers (i.e., labels) and physical alignment of the actions providing a basis for comparison and goal analysis.

Together, these findings support the conclusion that conceptual comparison is one factor that can contribute to infants' learning about others' intentional actions. It has long been hypothesized that the comparison between self and other provides infants with insights into others' actions (Barresi & Moore, 1996; Gerson & Woodward, 2010; Meltzoff, 2005; Tomasello & Moll, 2007). Moreover, recent findings by Gerson and Woodward (2012) support these hypotheses in showing that infants' action understanding is facilitated in contexts in which their own actions are aligned with those of others (see Moll and Tomasello, 2007, for related findings). The current results go beyond these hypotheses and findings in indicating that comparison can support infants' action understanding even when their own actions are not directly involved.

These findings raise new questions about the range of processes by which infants learn about others' intentional actions. To start, recent studies have found that infants' own actions provide information that can be used in understanding others' actions and that self-produced experience has stronger effects than observational experience on infants' understanding of those same actions in others (Gerson & Woodward, in press; Sommerville et al., 2005, 2008). Even so, the current findings, in combination with those of Gerson and Woodward (2012), suggest that similar cognitive processes allow infants to learn from both self-produced and observed actions. Comparison of aligned familiar and novel actions supported infants' action understanding whether the familiar actions were self-produced or observed, but in the case of observed actions, further support for comparison, in this case labeling, was needed. Thus, these findings suggest that self-produced action experience might be valuable because it provides a particularly strong base for analogical extension. At the same time, it is possible that direct matching between self-produced and observed actions provides unique support for action perception earlier in development or at the initial stages of action learning (see Gerson & Woodward, 2010).

Another body of work has shown that infants respond to abstract cues to goal directedness by treating the movements of novel entities—for example, efficient movement around barriers toward an object (e.g., Gergely & Csibra, 2003) and repeated, equifinal movements toward an object (e.g., Biro & Leslie, 2007)—as goal-directed. These findings have been taken as evidence that infants possess unlearned, abstract representations of intentions (Biro & Leslie, 2007; Gergely & Csibra, 2003; Luo & Baillargeon, 2010). The current findings raise the possibility that these abstract relational representations reflect the products of analogical learning from real-world actions.

The current findings raise questions concerning the role of language in the development of infants' action knowledge. Language supports later developments in social cognition, and in particular, theory of mind (see Astington & Baird, 2005; de Villiers, 2007; Hale & Tager-Flusberg, 2003; Lohmann & Tomasello, 2003; see also Baldwin & Saylor, 2005; Charman et al., 2000). The current findings suggest that the link between language and intention understanding emerges early in ontogeny and that labels support infants' detection of the relational similarity between familiar and novel actions in a way that nonword vocalizations do not. Importantly, findings from the nonalignment labeling condition indicate that the label during test trials was not sufficient to drive goal imitation in and of itself. Labels were only effective when they were presented with aligned exemplars. Several open questions remain, however, concerning the ways in which labels supported infants' analysis of the novel tool-use action.

For one, it is not clear whether the use of nouns was critical for the current effects. Prior research investigating the role of language in supporting cognitive learning in infants has used nouns, and further, has found that other word classes, such as adjectives, are in some cases less effective (Waxman & Leddon, 2011). These findings indicate that nouns are particularly salient to infants, and it was for this reason that we used them in the current study. However, research with older children has shown that language is most effective in highlighting relational similarities when the grammatical form of the language provides relational information—for example, in the use of prepositional phrases or relational nouns to denote a relational property (Gentner et al., 2011; Loewenstein & Gentner, 2005). Given these findings, it is possible that the effects observed in the labeling condition would be even stronger if we had used a grammatical class that mapped more transparently onto the relational structure of the event—for example, a verb.

Further, it is not clear whether the use of English words, rather than nonsense words, was critical for the current findings. Prior research documenting the effects of language on infants' categorization has mainly used nonsense words (e.g., *dax, blicket, toma*), even when the labeled items have English names that infants might know (Waxman & Leddon, 2011; but see Balaban & Waxman, 1997; Waxman & Markow, 1995). Further, research with older children has found similar effects with both familiar words (e.g., Loewenstein & Gentner, 2005) and nonsense words (e.g., Christie & Gentner, 2010). These findings, in conjunction with the lack of effect of labels in Study 2, suggest that familiarity with the specific words used may not have been important for the current findings. Further, given the age of the infants, it is unlikely that they were familiar with all of the 12 object names that were used. Although infants heard more variability in naming in the labeling condition than in the nonword vocalization condition, the fact that infants did not imitate the experimenter's goal above chance levels in the nonalignment labeling condition despite the variability in labels and the use of the same labels as in the labeling condition suggests that variability in labeling does not drive the effect. However, further studies are needed to evaluate this issue more thoroughly.

A final question concerns the extent to which infants are dependent on both labels and aligned exemplars to detect relational similarities in action. Prior studies with older children and adults have shown that although labels and aligned exemplars support analogical learning, learners (even infants) are sometimes able to detect relational similarities with one of these two supports alone (Casasola et al., 2009; Pruden & Hirsh-Pasek, 2006; Pruden, Shallcross, Hirsh-Pasek, & Golinkoff, 2008) and even without either of these supports, particularly when they have knowledge in the relevant domain (e.g., Loewenstein & Gentner, 2001, 2005; Ratterman & Gentner, 1998). The current findings suggest that these factors were important for 10-month-old infants' learning about a novel action. But given findings with older learners, it might be expected that infants would be able to detect relational similarities across actions without these supports (or with fewer supports) as they mature or for actions that are highly familiar. For example, in the current work, it is unclear whether the simultaneous presentation of both actions was critical for comparison. Infants in the present study always saw the hand- and tool-use actions act on the toy at the same time, but whether these actions must be physically copresent is unknown. It seems likely that physical copresence would be particularly beneficial early in development but that actions delayed in time and space may serve similar functions later in development (see Loewenstein & Gentner, 2001, for examples in the spatial domain). Future work is needed to address this possibility.

These issues aside, the current findings shed new light on the processes that contribute to infants' social understanding, and they add to a growing body of work elucidating the cognitive learning processes that operate during infancy. These results parallel findings in older children and adults that have demonstrated the role of comparison in relational learning and the role of labels in facilitating conceptual comparison (e.g., Casasola et al., 2009; Loewenstein & Gentner, 2005; Namy & Gentner, 2002). As in older children, comparison, facilitated by the presence of aligned exemplars, has been shown to support infants' detection of relational similarity (Gerson & Woodward, 2012; Pruden et al., 2008), as well as their analysis of novel categories (Oakes et al., 2009). Further, the use of labels to name instances has been shown to have a powerful effect on infants' propensity to form categories (Ferry et al., 2010; Fulkerson & Waxman, 2007; Waxman & Markow, 1995) and detect relational similarity (Pruden & Hirsh-Pasek, 2006). The current findings, together with these studies, indicate that infant learners have at their disposal some of the same conceptual tools that older learners have.

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