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Infant Discrimination of Faces in Naturalistic Events: Actions Are More Salient Than Faces

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Abstract

Despite the fact that faces are typically seen in the context of dynamic events, there is little research on infants' perception of moving faces. L. E. Bahrick, L. J. Gogate, and I. Ruiz (2002) demonstrated that 5-month-old infants discriminate and remember repetitive actions but not the faces of the women performing the actions. The present research tested an attentional salience explanation for these findings: that dynamic faces are discriminable to infants, but more salient actions compete for attention. Results demonstrated that 5-month-old infants discriminated faces in the context of actions when they had longer familiarization time (Experiment 1) and following habituation to a single person performing 3 different activities (Experiment 2). Further, 7-month-old infants who have had more experience with social events also discriminated faces in the context of actions. Overall, however, discrimination of actions was more robust and occurred earlier in processing time than discrimination of dynamic faces. These findings support an attentional salience hypothesis and indicate that faces are not special in the context of actions in early infancy.

Keywords

infant perception; face perception; action perception; selective attention

Faces have been shown to be highly salient to young infants and serve as an important source of information. They are more prevalent than other stimuli and convey information critical for interacting in the social world, including emotion, intention, and identity of individuals. Some researchers have proposed that faces represent a special stimulus category because they are processed differently from other stimuli (e.g., Tanaka & Farah, 1993; Tanaka & Sengco, 1997; Thompson & Massaro, 1989; Ward, 1989). Even in infancy, faces are thought to be special. Newborns are attracted to faces from hours after birth (Goren, Sarty, & Wu, 1975; M. H. Johnson & Morton, 1991) and orient to facelike patterns more than to permutated or inverted facelike patterns (Goren et al., 1975; Mondloch et al., 1999; Simion, Valenza, & Umiltá, 1998). Newborns also show recognition of the mother's face within hours of birth (Bushnell, 2001; Bushnell, Sai, & Mullin, 1989; Sai, 2005; Slater & Quinn, 2001).

Faces are typically perceived within the context of individuals engaged in multimodal, dynamic events. For example, infants participate in close face-to-face interactions with adults involving coordinated touch, sound, and movement during feeding, play, or changing. Infants observe

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adults engaged in routine activities such as cooking, eating, and conversing. However, research has rarely investigated face perception within the context of people performing everyday activities. Which aspects of these “person events” are most salient and attended and which aspects are ignored in this complex, dynamic array? Under what conditions are faces selectively attended in the context of natural events, and when are they ignored?

Bahrick, Gogate, and Ruiz (2002) addressed these questions by assessing infants’ perception and memory for the faces versus the actions of women engaged in everyday activities. They found that 5-month-old infants detected and showed remarkable memory for everyday, dynamic activities, but surprisingly showed no evidence of detecting or remembering the face of the individual performing the activity. Infants were familiarized with a woman engaged in a repetitive activity (e.g., brushing hair, brushing teeth, blowing bubbles). Then, in a two-screen novelty preference test, infants received test trials depicting a novel versus a familiar woman performing the familiar action (face test) and other test trials depicting the familiar woman performing a novel versus the familiar action (action test). Results indicated clear discrimination of the actions by a novelty preference but no discrimination of the faces. Infants also showed long-term memory for the actions following a 7-week delay (by a familiarity preference) but no memory for the faces. These findings demonstrate remarkably long-lasting memory for actions and no discrimination or memory for faces in the context of actions. Surprisingly, a control study demonstrated face discrimination only when the faces were shown in static poses. A further control study confirmed that it was the actions (brushing hair, brushing teeth, blowing bubbles) that were salient and discriminated by infants rather than the objects, which also varied with the activities (hair brush, toothbrush, bubble wand). Infants discriminated a change in activity even when there was no object change but did not discriminate a change in the object in the context of the same activity. Together, these results highlight the salience of actions over the faces of individuals engaged in actions and the superiority of face perception and memory for static face displays over faces engaged in actions for young infants. Our findings of poor face perception in the context of dynamic events contrast with recent findings of infants’ remarkable face processing skills and the suggestion that faces are highly salient and preferred over other stimuli (e.g., Goren et al., 1975; M. H. Johnson & Morton, 1991; Mondloch et al., 1999; Simion et al., 1998; Slater & Quinn, 2001).

Despite the fact that faces typically occur in the context of individuals engaged in dynamic events, face recognition has typically been assessed using static faces. In static presentations (e.g., photographs or line drawings), infants have been shown to discriminate two unfamiliar adult faces (Cohen & Strauss, 1979; de Haan, Johnson, Maurer, & Perrett, 2001), an own-race face from an other-race face (Sangrigoli & de Schonen, 2004), and even between faces of primates (Pascalis, de Haan, & Nelson, 2002). Infants have also shown face recognition after a 24-hr (Pascalis, de Haan, Nelson, & de Schonen, 1998) and a 2-week delay (Fagan, 1973). Furthermore, infants are quite skilled at abstracting important information from faces, even in static displays. For example, 3-month-olds abstract a prototype from a series of four static faces (de Haan et al., 2001); 5-month-olds recognize a familiar face from a static image, despite changes in emotional expression (Bornstein & Arterberry, 2003); and 6-month-olds prefer attractive faces based on a prototype or averaged face (Langlois & Roggmann, 1990; Rubenstein, Kalakanis, & Langlois, 1999).

Even studies that employ live or videotaped faces typically present the face as still or engaged in minimal movement. Newborns discriminate a live, still display of their mother’s face from that of a stranger (Bushnell et al., 1989; Field, Cohen, Garcia, & Greenberg, 1984; Sai, 2005), and by 1 month of age, they discriminate her face even when external features have been masked (Pascalis, de Schonen, Morton, Dereulle, & Fabre-Grenet, 1995). Between 2 and 5 months of age, infants can discriminate between the live, still faces of two unfamiliar women on the basis of both internal and external features (Blass & Camp, 2004), and by 6 months they

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categorize faces on the basis of gender (Newell & Strauss, 2002). Studies of intersensory perception of face–voice relations during audiovisual speech also provide evidence of infants' perception and discrimination of dynamic faces of unfamiliar individuals. Bahrick, Hernandez-Reif, and Flom (2005) found that infants of 4 and 6 months of age, but not 2 months of age, could detect a change in the face–voice pairing of two unfamiliar adults of the same gender during audiovisual speech (see also Brookes et al., 2001). This required discriminating the two faces, discriminating the two voices, and detecting a relation between them. Infants of 4 to 8 months of age also match faces and voices on the basis of gender and age (Bahrick, Netto, & Hernandez-Reif, 1998; Patterson & Werker, 2002; Walker-Andrews, Bahrick, Raglioni, & Diaz, 1991). Further, Bahrick and colleagues found that infants discriminated the faces of unfamiliar women engaged in unimodal visual speech by 2 months of age and in bimodal audiovisual speech by 3 months of age (Bahrick, Lickliter, Vaillant, Shuman, & Castellanos, 2004a, 2004b). Thus, infants perceive and discriminate faces of unfamiliar adults engaged in natural events that involve limited movement, such as audiovisual speech, by 3 or 4 months of age. However, little is known about infants' perception of faces of people engaged in complex, dynamic activities.

Moreover, research has suggested that perception and memory for moving faces is better than for static faces. Although the majority of adult face-perception research is also conducted using static images (see De Jong, Wagenaar, Wolters, & Verstijnen, 2005; Leder & Carbon, 2005; Lewis, 2004; Peskin & Newell, 2004, for example), research has shown that nonrigid, natural movement (as in speaking or changing expressions) enhances memory for familiar faces (Knight & Johnston, 1997; Lander & Bruce, 2000, 2003, 2004; Lander, Christie, & Bruce, 1999; Lander & Chuang, 2005; Pike, Kemp, Towell, & Phillips, 1997). Research suggests that infants, like adults, may also discriminate and remember dynamic faces more easily than still faces. Bahrick, Moss, and Fadil (1996) found that young infants could discriminate their own face from that of a peer only when the faces were engaged in natural movement and not when they were still, whereas older infants could discriminate the faces under both moving and still conditions.

Enhanced discrimination of dynamic over static faces is consistent with findings that movement facilitates abstracting the form of objects. For example, infants detect structure from the biomechanical motion of point light displays and perceive a human walking in moving but not static point lights (Bertenthal, Proffitt, & Cutting, 1984). Infants also perceive the form of a partially occluded object better when it is moving than when it is static. Thus, young infants (2–4 months) detect the form of the occluded portion of an object when it is moving (e.g., S. P. Johnson, Cohen, Marks, & Johnson, 2003; Kellman & Spelke, 1983), but only older infants (8 months) do so when it is static (Craton, 1996; Kellman & Spelke, 1983). Infants are also adept at abstracting other important types of information from motion (see Kellman & Arterberry, 1998, for a review). Infants differentiate the self from a peer on the basis of visual information contingent with their own body motion (Bahrick & Watson, 1985; Rochat, 1995; Rochat & Morgan, 1995; Schmuckler, 1996), and they abstract information about object composition and substance (Bahrick, 1983, 1987, 1988, 1992), social and nonsocial causality of events (Oakes, 1994; Rochat, Striano, & Morgan, 2004), and intentionality of human action (Woodward, 1999) from dynamic, multimodal events. Infants also form categories on the basis of dynamic information. Six-month-olds categorize point light displays of animals and vehicles on the basis of motion alone (Arterberry & Bornstein, 2002) and older infants (22 months) form categories based on the way an object or its features move (i.e., arms flapping vs. spinning; Rakison, 2004). Thus, infants abstract information about a wide range of meaningful properties of objects on the basis of motion.

Although infants abstract meaningful information through motion, little research has assessed infants' discrimination of and memory for the actions themselves. The small body of research

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on this topic indicates that even young infants are excellent at discriminating and remembering activities. For instance, they can identify discrete, meaningful units of action from a continuous display of movement (Baldwin, Baird, Saylor, & Clark, 2001; Sharon & Wynn, 1998) and discriminate an event specifying social causality from one in which the agents move independently (Rochat, Morgan, & Carpenter, 1997). Infants also demonstrate long-term memory for the motions of objects. They remember the contingency between self-motion and the movement of a crib mobile, as well as features of the mobile, even after delays of 24 hr or more (Bhatt & Rovee-Collier, 1994; Greco, Rovee-Collier, Hayne, Griesler, & Earley, 1986; Rovee-Collier & Barr, 2001). Moreover, they can remember and discriminate object motions, such as swinging versus circular motion, across a period of at least 3 months (Bahrick, Hernandez-Reif, & Pickens, 1997; Bahrick & Pickens, 1995; Courage & Howe, 1998). However, few studies provide insight into infants' discrimination of faces engaged in natural activities or their memory for the faces or activities.

In contrast to movement enhancing perception of faces, however, Bahrick et al. (2002) found that actions attenuated perception of faces at 5 months of age. In fact, face recognition was limited to images of static faces. These findings converge with others in the literature. By 5 months of age, infants have shown exceptional recognition for static faces (e.g., de Haan et al., 2001; Pascalis et al., 1995, 1998). Moreover, Xu, Carey, and Quint (2004) concluded that younger infants detect changes in objects on the basis of actions, whereas only older infants detect changes based on featural information.

Why do infants demonstrate such poor face recognition skills in the context of naturalistic, everyday events? Under what conditions do infants perceive form through motion, and under what conditions do they perceive the activity or motion itself with attenuated attention to form? Bahrick et al. (2002) proposed an "attentional salience" hypothesis to explain why infant memory and attention to activities was superior, whereas memory and attention to faces in the context of activities was poor. It was hypothesized that the observed failure of face discrimination did not reflect an inability to perceive faces in the context of dynamic events. Rather, it was the result of earlier and greater attentional selectivity to the actions than to the faces.

Because attention capacity is limited, and there is a great deal more stimulation available at any time and in any given event than can be attended to or perceived, attention always involves selecting some information as a focus, at the expense of other information (Gibson, 1969; Neisser, 1976; Ruff & Rothbart, 1996). According to the attentional salience hypothesis, there is an implicit salience hierarchy that guides selective attention, in that more salient information is attended to and processed first, and less salient information is processed later in exploratory time. This notion of a hierarchy is consistent with a differentiation view of perceptual development (Gibson, 1969) as well as a levels-of-processing framework (Adler, Gerhardstein, & Rovee-Collier, 1998; Craik & Lockhart, 1972). Selective attention (focusing attention on more salient information first) is guided in early infancy by aspects of stimulation such as movement, stimulus intensity, intersensory redundancy, and novelty, as well as goals and immediate needs (Bahrick & Lickliter, 2000, 2002; Gibson & Pick, 2000; Ruff & Rothbart, 1996; Schnierla, 1959), and later in development it comes under more voluntary control and is more context sensitive (Ruff & Rothbart, 1996). Selective attention can be directed to different objects or events in the visual field, as well as to different aspects of single events (e.g., Bahrick & Lickliter, 2002; Bahrick, Walker, & Neisser, 1981; Coldren & Colombo, 1994; Colombo, Freeseman, Coldren, & Frick, 1995; Ruff & Rothbart, 1996). Further, selectivity is assumed to be dynamic, depending on the internal state and goals of the perceiver and the stimulative qualities of objects and events, as well as their novelty value to the perceiver. Given that attention capacity is limited, particularly during infancy, selective attention to more salient aspects of events necessarily attenuates attention to less salient aspects. By varying

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dimensions along which novel and familiar events differ, one can determine which aspects of events infants selectively attend to and which are relatively ignored.

The present studies were designed to (a) determine under what conditions infants perceive faces in the context of dynamic events and (b) test the attentional salience hypothesis as an explanation for poor dynamic face recognition at 5 months of age. If the attentional salience of action interferes with face discrimination, then infants should detect faces in the context of actions when the actions are less salient. Experiment 1 assessed whether longer exposure time to the events would familiarize infants more fully with the actions, decreasing their attentional salience and eventually facilitating attention to and discrimination of the faces in the context of the actions. Experiment 2 assessed whether infants who are presented with a particular individual engaging in multiple activities would abstract the invariant face and generalize across activities, thus enhancing face perception in the dynamic events. Finally, Experiment 3 investigated whether older infants would detect both the actions and the faces in the context of dynamic actions (using procedures identical to Bahrick et al., 2002), given that older infants process information more quickly and have more attentional flexibility than younger infants do.

Experiment 1

Method

Participants—Twenty-four 5.5-month-old infants (*M* = 164 days, *SD* = 5 days), 13 girls and 11 boys, participated. Seven additional infants were excluded from the final sample due to experimenter error (*n* = 2), equipment failure (*n* = 2), fussiness (*n* = 2), or failure to meet the attention criterion (*n* = 1; see the *Procedure* section for details). All infants were healthy and full-term, weighing at least 5 lbs at birth, with Apgar scores of 9 or higher. They were primarily from middle-class families. Fifteen were Hispanic, 5 were Caucasian, 1 was Asian, 1 was African American, and 2 were of mixed racial backgrounds.

Stimuli—The events were identical to those used in Bahrick et al. (2002). They consisted of nine video displays of three different women performing three different repetitive actions: brushing their teeth, blowing bubbles, or brushing their hair (see Figure 1). These actions were selected because they were repetitive, everyday events that attracted attention to the area of the face. While performing the activities, the women's faces were shown in three different orientations (facing center, left, right and again center), shifting direction approximately every 10 s. A special effort was made to perform the activities in the same way and to control for affect as closely as possible across the various actresses. While performing the actions during filming, each actress mimicked the actions of a model actress. The model maintained a neutral expression during the 10-s cycle, looking primarily toward the camera, and then smiled once at the end of each cycle. The actresses were selected to be highly distinguishable based on appearance. One was White with light skin and long, light brown hair (Woman 1); the second was Asian Indian with brown skin and wavy, dark brown hair (Woman 2); and the third was Chinese with a light complexion and long, straight black hair (Woman 3; see Figure 1).

Apparatus—Infants sat in a standard infant seat facing two color TV monitors (Sony KV-20M10) approximately 50 cm away. The video displays were presented using three video decks (Panasonic AG 6300 and Panasonic AG 7750). A rattle on a string, located between the monitors, was used to center the infant's attention between trials. Two apertures cut into a black poster board placed above the monitors served as peepholes for monitoring infants' visual fixations to the displays. Visual fixation was measured by one or two observers who pressed one of a pair of buttons while the infant visually fixated on the right monitor and the other button while the infant fixated on the left monitor. The observers' button presses were recorded

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online using a computer (Dell Optiplex GX260) and printed (HP Deskjet 990cse) in an adjacent room.

Procedure—Twenty-four infants were familiarized during eight 40-s trials to one of three dynamic displays of an unfamiliar woman performing a repetitive activity. Procedures were similar to those of Bahrick et al. (2002) except that infants received twice the familiarization time (eight 40-s trials compared with four 40-s trials). Infants were randomly assigned to one of three displays for familiarization: Woman 1 brushing her teeth, Woman 2 brushing her hair, or Woman 3 blowing bubbles (n = 8 per group). Two identical films of the same event were displayed side-by-side, but out of phase with one another, on the two video monitors. An attention criterion was imposed to eliminate the data of infants who had not attended sufficiently during familiarization to support later memory for the displays (see Bahrick et al., 2002). Infants were required to attend for at least 160 s of the total 320 s available (50% of the time). This ensured that minimum looking time was at least twice that of infants in the prior study, who were required to attend 80 s of the 160 s available (50% of the time).

One min following familiarization (during which time the parent entertained the infant in the seat), infants received a two-choice novelty preference test for the faces and actions across four 30-s trials, two trials for each type of test. The face tests consisted of trials of the familiar face shown side by side with a novel face, with both women performing the familiar action (out of phase with one another). The action tests consisted of trials of the familiar action alongside a novel action, with both actions performed by the familiar woman. The face and action test trials were presented in alternation, and their order of occurrence was counterbalanced such that 12 subjects received an action test trial first and 12 subjects received a face test trial first. In addition, the lateral positions of the novel display were varied across trials and counterbalanced across subjects. Half the infants received the novel display on the left or right monitors in one sequence (RLLR), whereas the other half received the opposite sequence (LRRL). Each standard served as the familiarization display and the 1-min memory test display equally often, and each pair of faces and each pair of actions were contrasted equally often.

Trained observers, blind to the lateral positions of the displays, the person, and the type of activity, recorded infants' visual fixation to the displays. Reliability was calculated by comparing the judgments of right and left looking scores across two observers for 6 subjects (25% of the data). The Pearson product-moment correlation for the primary and secondary observers' scores was 0.87 (SD = 0.14) for the familiarization phase and 0.93 (SD = 0.08) for the 1-min memory test.

Results and Discussion

Familiarization phase—The mean number of seconds of looking to the familiarization displays out of a total of 320 s was 253.73 s (SD = 32.31) or 79%. The mean proportion of infants' visual fixation time across the eight familiarization trials was evaluated to assess stimulus preferences across the three standard events: Woman 1 brushing her teeth, Woman 2 brushing her hair, and Woman 3 blowing bubbles. A one-way analysis of variance (ANOVA) on the proportion of looking during the familiarization trials showed no main effect of stimulus event, $F(2, 21) = 0.30$, $p > .1$, ES (effect size) =.03.[1] Infants showed no a priori preferences for one stimulus display over another.

Memory test phase—For the 1-min delay, the proportion of time that infants spent looking at one of the two side-by-side test displays during the action test trials was 0.72 (SD = 0.18),

[1]In cases of independent-samples *t* tests, paired-samples *t* tests, and one-way ANOVAs, eta-squared is reported. In cases of multivariate ANOVAs, partial eta-squared is reported. In cases of one-sample *t* tests, a paired-samples *t* test comparing looking times to novel and familiar stimuli was conducted, and eta-squared was calculated from the *t* statistic.

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and during the face test trials was 0.69 (*SD* = 0.19). These means did not differ from one another, $t(23) = 1.28$, $p > .1$, ES =.07, 95% confidence interval (CI_{95}) = −0.02, 0.09.

The proportion of infants' total looking time (PTLT) to the novel faces or actions served as the primary dependent variable, as in the prior study. It was calculated for each subject and each trial of the delay period by dividing the time spent looking at the novel display by the total time spent looking at both concurrent displays. The mean PTLT for the action test was obtained by averaging the PTLTs for the two action test trials for a given subject, and the mean for the face test trials was obtained by averaging the PTLT for the two face test trials. Mean proportions across subjects are depicted in Figure 2 alongside the PTLTs from the original study (Bahrick et al., 2002).

To determine whether infants showed significant evidence of memory for the face and the action, the mean PTLTs were compared against the chance value of 50% in one-sample *t* tests. Results indicated that after the 1-min delay, infants showed a significant preference for the novel action, $t(23) = 2.95$, $p < .01$, ES =.27, CI_{95} = 0.53, 0.64, replicating results of the prior study. In contrast to the prior results, however, infants also showed a significant preference for the novel face, $t(23) = 2.18$, $p < .05$, ES =.17, CI_{95} = 0.50, 0.62.

Secondary analyses were also conducted to determine whether differences existed between groups of infants who received different orders of test trials (AFAF vs. FAFA). A Test Order (AFAF vs. FAFA) × Test Type (face vs. action) mixed model ANOVA was conducted. There was a marginal main effect of test order, $F(1, 22) = 3.89$, $p = .06$, ES =.15. Infants tested in the AFAF order showed higher overall novelty preferences (to both the face and action trials), $M = .61$ ($SD = .02$), CI_{95} = 0.56, 0.66, than infants tested in the FAFA order, $M = .54$ ($SD = .03$), CI_{95} =0.48, 0.59, or CI_{95} (mean difference) = 0.00, 0.15. There was no main effect of test type, $F(1, 22) = .35$, $p > .10$, ES =.02, or interaction of test type and test order, $F(1, 22) = 1.71$, $p > .10$, ES =.07. Thus, there were no differences in discrimination ability for faces versus actions, and the test order effect did not differentially affect one test type more than the other.

The data were also examined at the individual subject level and evaluated with nonparametric tests. For the action test trials, 18 of the 24 infants showed a novelty preference at the 1-min delay, $p = .05$ according to a binomial test, paralleling results of the parametric tests. For the face test trials, only 16 of the 24 infants showed a novelty preference at the 1-min delay, $p > .10$ according to a binomial test, indicating that face perception is not consistently shown across individual subjects.

These results, taken together with those of Bahrick et al. (2002), indicate that infants were able to discriminate both the actions and the faces in dynamic events when available familiarization time was doubled from 160 s to 320 s. These findings demonstrate that infants are able to perceive and remember faces in the context of dynamic actions, but they require more exposure time to detect faces than actions (M = 253.73 s, SD = 32.31 s vs. M = 152.50 s, SD = 15.76 s), and detection of faces is not consistently shown across subjects. These findings are consistent with the attentional salience interpretation of the prior findings. That is, infants are able to perceive faces in dynamic actions; however, the actions are more salient. Once infants have received sufficient familiarization to the actions, later in processing, they attend to and differentiate the faces engaged in the actions.

Experiment 2

Experiment 2 provides another avenue for assessing the conditions under which infants discriminate faces engaged in dynamic activities and for evaluating the attentional salience hypothesis. Consistent with research traditions in the areas of concept formation, categorization, and invariant detection, presenting multiple exemplars of a category,

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opportunities for variable training, or information that is invariant across transformation has been found to facilitate attention, habituation, learning, and memory of information that is common or invariant across presentations and to facilitate generalization across aspects that vary, for both infants and adults (e.g., Bomba & Siqueland, 1983; Gibson,1969; Hayne, 1996; Mandler, 1998; Mervis & Rosch, 1981; Needham, Dueker, & Lockhead, 2005; Quinn, 1987; Rovee-Collier & Gulya, 2000). For example, Needham et al. (2005) found that infants required three exemplars to form a category, and variability in the exemplar set was necessary. Thus, to promote abstraction of the concept "red" and generalization across different shapes, one could habituate infants with a red square, red circle, and red diamond. Visual recovery would be predicted to a blue triangle, but not to a red triangle, if the participant had abstracted red and generalized across various shapes. It is well established that infants are adept at abstracting invariants across change (e.g., Bahrick & Lickliter, 2002; Bahrick & Pickens, 1994; Gibson, 1969; Gibson & Pick, 2000; Walker-Andrews, 1997). Abstracting invariants focuses attention on stimulation that remains constant across a background of change (akin to a "pop out" or figure–ground effect), and this leads to perceptual differentiation of the more salient aspects of stimulation prior to other aspects (Bahrick, 1988, 1992; Bahrick et al., 1981; Bahrick & Lickliter, 2002; Bahrick, Lickliter, & Flom, 2004; Flom & Bahrick, 2007; Gibson, 1969; Walker-Andrews, 1997). Consequently, attentional salience leads to longer, deeper, and earlier processing and perceptual differentiation of the salient aspects of stimulation (Adler, Gerhardstein, & Rovee-Collier, 1998; Bahrick & Lickliter, 2002; Craik & Lockhart, 1972; Gibson, 1969). Further, because attentional capacity is limited, particularly during infancy, selective attention to some aspects of stimulation (more salient) always occurs at the expense of attention and processing of other aspects (less salient; e.g., Neisser, 1976; Ruff & Rothbart, 1996).

This logic guided the design of the present study. If actions are typically more salient than faces, then one can decrease the attentional salience of the actions and enhance the attentional salience of the faces by presenting the same woman engaged in three different activities. This should recruit more attention to the face because it is invariant across activities and facilitate generalization across actions because they vary. In other words, the exposure to various examples of the same woman engaged in different actions should promote selective attention and perceptual processing of her face and attenuate selective attention and perceptual processing of her actions, such that infants categorize the various displays of her face as similar and abstract information—something like "Susie performing an activity." In contrast, exposure to a woman performing a single activity appears to promote abstraction and perceptual processing of the activity at the expense of the face, presumably because of the salience of the actions to 5-month-olds (Bahrick et al., 2002). Prior research assessing infant perception of static faces using a similar design has demonstrated that infants can abstract a common face across changes in pose (Fagan, 1976), and emotional expressions (Bornstein & Arterberry, 2003) and can form a prototype from across four static faces (de Haan et al., 2001).

Thus, in the present experiment, we hypothesized that if infants' inability to discriminate faces of women engaged in activities in Bahrick et al. (2002) was due to greater attention to actions at the expense of the faces, then infants should show face discrimination in the present study where the variable training format increases the attentional salience of faces relative to the actions. Infants were habituated to videos of a woman performing three different activities. Following habituation, we tested infants' ability to detect a face change by assessing their visual recovery to a change in face and action (face test) and a change in action only (control test). It was predicted that if infants attended to the invariant face across changes in dynamic activities, then they would show visual recovery to the face test (change in face plus action) but not to the control test (change in action alone) and recovery to the face test would be greater than to the control test.

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Method

Participants—Twenty-four healthy 5.5-month-old infants (*M* = 163 days, *SD* = 3 days), 10 girls and 14 boys, participated. Fourteen additional infants were excluded from the final sample due to experimenter error (*n* = 3), equipment failure (*n* = 3), fussiness (*n* = 4), or failure to meet the attention or habituation criteria (*n* = 4; see the *Procedure* section for details). Infants were primarily from middle-class families. Of these infants, 4 were Caucasian and 20 were Hispanic.

Stimuli—The stimuli were identical to those used in Experiment 1, except that an additional activity (i.e., applying makeup) was included for each woman and an additional woman was filmed performing all four activities. Woman 4 was Caucasian with very short, dark hair (see Figure 1). As with the other three activities, while performing the activity, the women were shown changing position to face a different direction every 10 s (center, left, right, and again center). This activity was filmed in the same manner as the other three activities. A control display depicted a green and white toy turtle whose arms spun, making a whirring sound.

Apparatus—The apparatus was identical to Study, 1 except that only one monitor was used to display the stimulus events.

Procedure—Infants were tested to determine whether they could detect a change in face plus action, but not action alone, following exposure to an unfamiliar woman performing three different, everyday activities in an infant-controlled habituation procedure (see Horowitz, 1975; Horowitz, Paden, Bhana, & Self, 1972). Infants received habituation to one of four women (*n* = 6 per condition) performing three different actions in successive trials (Action 1, 2, 3, 1, 2...), one action per trial. Thus, each infant was habituated to a series of trials in which one woman was presented performing three different, everyday activities. The fourth action served as the novel action for both the face test and the control test. Actions were grouped into four orders and counterbalanced such that each grouping of actions was used six times. Each woman served as the novel face for the face test equally often.

The habituation sequence was initiated with a control trial (the toy turtle) to measure baseline interest for the purpose of assessing fatigue. Four mandatory habituation trials were then presented, and additional trials were presented until the infant's visual fixation level decreased by 50% or more on two consecutive trials, relative to the infant's baseline fixation level (the mean of the fixation on the first two habituation trials). Each trial began when the infant fixated the visual display and was terminated after the infant looked away for 1.5 consecutive seconds. Further, a ceiling of 60 s was set as the maximum trial length, and 20 trials was the maximum number of trials for habituation. Once the criterion was met, two no-change posthabituation trials were presented. These two additional habituation trials were presented to establish a more conservative habituation criterion by reducing the possibility of chance habituation and allowing spontaneous regression toward the mean (see Bertenthal, Haith, & Campos, 1983, for a discussion of these effects). Following the two no-change posthabituation trials, each infant received two pairs of test trials, one pair depicting a change in action only, in which the familiar woman was seen performing the fourth activity, and another pair depicting a change in face and action, in which the unfamiliar woman was seen performing the unfamiliar activity. The order of test trials was counterbalanced across infants. Two additional habituation trials were presented between the pairs of test trials to reestablish post-habituation interest levels. Infants then received a final control trial (the toy turtle), which served as a basis for assessing fatigue.

Discrimination was inferred when the visual fixation time during the test trials (depicting a new event) showed a significant increase (visual recovery) relative to that of the visual fixation time during the two posthabituation trials. Significant visual recovery to the change in action-

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only test trials (control test) would indicate that infants attended to and discriminated the different activities. Significant visual recovery to the change in face and action test trials (face test) would indicate that infants attended to and discriminated the face or the action change. Significant recovery to the face and action test trials, but not the action-only (control) trial, would demonstrate that infants attended to and discriminated the face of the individual across varying activities but did not differentiate the individual activities and subsequently discriminated a novel face engaged in a dynamic action.

Each trial began when the infant visually fixated the monitor and was terminated when the infant looked away for at least 1.5 s (or once 60 s of looking was accumulated). Infants were considered unable to habituate if they failed to reach the habituation criterion within 20 trials. The data of three infants were rejected for this reason. The infants' data were examined to ascertain whether two criteria had been met, one to identify fatigue and the other to ensure that infants who reached the habituation criterion had, in fact, habituated (see Bahrick, 1992, 1994; Bahrick & Lickliter, 2000). To make certain that infants were not overly fatigued and unable to show visual recovery, we compared their visual fixation to the toy turtle on the final control trial with that of the initial control trial. A visual fixation to the toy turtle on the final control trial that was at least 35% of the initial fixation level to the turtle was set as a minimum criterion for inclusion. No infants were rejected for this criterion. All infants showed substantial visual fixation on the final control trial (*M* = 185% of the fixation level on the initial control trial). In addition, to evaluate whether infants had, in fact, habituated to the events, we compared infants' mean fixation level on the two posthabituation trials with their mean initial fixation level (baseline). The data of any infant whose posthabituation fixation level exceeded their baseline fixation level were excluded (*n* = 1).

A secondary observer monitored the visual attention of 12 infants (50% of the sample) for assessing interobserver reliability. Length of visual fixation was calculated for each trial for each infant and each observer. A Pearson product-moment correlation was computed between the observations of the primary and secondary observers and averaged.93 (*SD* =.08).

Results and Discussion

Infants spent an average of 227.7 s (*SD* = 118.5) attending to the events during the habituation phase. Their initial interest level (baseline looking), an average of the first two habituation trials, was 36.0 s (*SD* = 18.3), and their final level of interest during the two no-change posthabituation trials averaged 14.27 s (*SD* = 11.4).

The primary measure used as the index of discrimination was visual recovery to the face/action versus the action test trials. Visual recovery, a difference score, was computed for each infant by subtracting the mean number of seconds looking during the two no-change posthabituation trials from the mean number of seconds looking during each pair of test trials. To assess discrimination of the invariant face across changes in action, we assessed visual recovery to the face/action test trials versus the action test trials (see Figure 3). Infants were predicted to show visual recovery to the face/action trials, but not the action trials.

To examine whether infants discriminated a change in action, we conducted a single sample *t* test on infants' mean visual recovery to the action change trials against the chance value of 0 (all tests were two-tailed). Consistent with our prediction, the results were nonsignificant, $t(23) = 0.19$, $p = .85$, ES =.05, $CI_{95} = -6.16, 7.40$, and indicate that 5.5-month-old infants generalized across three different actions to a fourth, novel action. To examine whether infants discriminated a change in face and action, we conducted a single sample *t* test on the mean visual recovery to the face/action change trials against the chance value of 0. The results were significant, $t(23) = 2.99$, $p < .01$, ES =.73, $CI_{95} = 3.28, 18.05$, and indicate that 5.5-month-old infants discriminated a change in face and action when habituated to three different actions

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performed by the same woman. Moreover, a paired-samples *t* test demonstrated that the visual recovery to the face/action test trials was significantly greater than that of the action test trials, $t(23) = 2.71$, $p < .05$, ES =.61, CI_{95} (mean difference) = 2.38, 17.71, demonstrating evidence of face discrimination in the context of actions.

In addition, we examined the data at the individual subject level to determine whether the results were characteristic of the group as a whole or were primarily carried by a few infants. Recovery scores for the face/action test trials and the action test trials were classified as positive or negative, and binomial tests were conducted to assess whether the number of infants who showed positive visual recovery scores was significantly greater than chance (.50). Eleven of the 24 infants showed positive visual recovery scores ($p > .1$) for the action test trials, a nonsignificant result paralleling those of the *t* tests. In contrast, 18 of the 24 infants showed positive visual recovery scores ($p < .05$) for the face/action trials, and 18 of the 24 infants showed a greater visual recovery for the face/action test trials than the action test trials ($p < .05$). These findings converge with those of our parametric tests and indicate that the results were not carried by a few infants.

Analyses were also performed to assess whether the effects were consistent across the four habituation faces (i.e., Women 1, 2, 3, and 4). A mixed model ANOVA was performed with visual recovery scores for action test trials vs. face/action test trials as a repeated measure and face (Woman 1 vs. 2 vs. 3 vs. 4) as a between-subjects factor. There was a main effect of test type, $F(1, 20) = 10.56$, $p < .01$, ES =.35, due to the greater visual recovery to the face/action test trials than the action test trials, mirroring the results of the paired-samples *t* test. There was no main effect of habituation face, $F(3, 20) = 1.37$, $p > .10$, ES =.17. However, there was a Test Type × Habituation Face interaction, $F(3, 20) = 4.34$, $p < .05$, ES =.39. The visual recovery to the face/action test trials was greater than the visual recovery to the action test trials for all faces except Woman 3 ($M = 10.52$ vs. 16.35).

Secondary analyses were also conducted to assess stimulus preferences by comparing performance among habituation conditions (Woman 1, 2, 3, or 4) to determine whether initial interest level (baseline), final interest level (posthabituation), number of trials to habituation, or total processing time (seconds looking during habituation and no-change posthabituation trials) for the events differed as a function of condition. Four one-way ANOVAs were conducted, one for each variable, with habituation condition (Woman 1, 2, 3, and 4) as the main factor. The analyses revealed nonsignificant effects for all four measures (*p*s >.1). Thus, the infants did not differ in their initial interest, final interest, number of trials to habituation, or total processing time for the face of one woman over another.

Overall, these results indicate that 5.5-month-old infants can discriminate among the faces of unfamiliar women performing everyday activities. They abstracted a common face across three different activities and discriminated a novel face of a woman performing a novel action but did not discriminate a novel activity alone. These findings contrast with those of the prior study (Bahrick et al., 2002) where 5.5-month-old infants showed no discrimination between faces of women performing everyday actions. Thus, it appears that when 5.5-month-old infants are habituated to a series of activities in which the face of the person performing the activity is invariant, attention is recruited to the face and generalizes across actions. Taken together, Experiments 1 and 2 demonstrate that when attention to the activities is attenuated, 5.5-month-old infants can discriminate the face of an unfamiliar person performing an activity.

Experiment 3

This experiment investigated whether 7-month-old infants are able to detect both the actions and the faces in the context of dynamic actions, in a procedure identical to Bahrick et al. (2002). They demonstrated that 5.5-month-old infants showed no evidence of discriminating

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or remembering the face of a person who was engaged in a dynamic activity on the basis of 160 s available familiarization time. Instead, infants showed robust discrimination and memory for the action. However, Experiment 1 indicated that with additional exposure time (320 s vs. 160 s), 5.5-month-old infants were able to discriminate faces in the context of dynamic activities. Because older infants process information more quickly than younger infants (Rose, Feldman, & Jankowski, 2002) and have had more experience with the faces and actions of adults, we reasoned that they would show improved ability to detect faces in the context of actions. Further, infants appear to show significant improvement in a variety of related face processing skills between 4 and 7 months of age, including categorization of faces on the basis of gender (emerges at 6 months; Newell & Strauss, 2002), intermodal matching of dynamic faces and voices on the basis of gender (improves from 4 to 6 months; Walker-Andrews et al., 1991), matching specific faces and voices of unfamiliar adults (present at 7 but not 5 months; Bahrick et al., 1998), discriminating the static face of a peer from that of the self (present at 8 but not 5 months; Bahrick et al., 1996), and discriminating affect in dynamic, speaking faces across increasingly more difficult contexts (4-month-olds show audiovisual discrimination, 5-month-olds show auditory discrimination, and 7-month-olds show visual discrimination; Flom & Bahrick, 2007). Experiment 3 thus assessed whether infants of 7 months would discriminate the faces as well as the actions following the short familiarization time (160 s). Further, would actions still be more salient than faces for older, more experienced infants?

Method

Participants—Twenty-four 7-month-old infants (*M* = 210 days, *SD* = 4 days), 10 girls and 14 boys, participated. Eleven additional infants were excluded from the final sample due to experimenter error (*n* = 2), equipment failure (*n* = 3), side bias (*n* = 2), or failure to meet the attention criterion (*n* = 4; see the *Procedure* section for details). All infants were healthy and full-term, weighing at least 5 lbs at birth, with Apgar scores of 9 or higher. They were primarily from middle-class families. All infants were Hispanic.

Apparatus and procedure—The apparatus and procedure was the same as Experiment 1, except that there were only four 40-s familiarization trials (identical to Bahrick et al., 2002).

Trained observers, blind to the lateral positions of the displays, the person, and the type of activity, recorded infants' visual fixation to the displays. Reliability was calculated by comparing the judgments of right and left looking scores across two observers for 8 subjects (33% of the data). The Pearson product-moment correlation for the primary and secondary observers' scores was 0.86 (*SD* = 0.28) for the familiarization phase and 0.97 (*SD* = 0.02) for the 1-min memory test.

Results and Discussion

Familiarization phase—The mean number of seconds of looking to the familiarization displays out of a total of 160 s was 121.93 s (*SD* = 19.89) or 76%. The mean proportion of infants' visual fixation time across the four familiarization trials was evaluated to assess stimulus preference across the three standard events: Woman 1 brushing her teeth, Woman 2 brushing her hair, and Woman 3 blowing bubbles. A one-way ANOVA on the proportion of looking time during the familiarization trials showed no main effect of stimulus event, $F(2, 21) = 0.74$, $p > .1$, ES =.07. Thus, infants showed no a priori preferences for one stimulus display over another.

Memory test phase—The mean proportion of time that infants spent looking at one of the two side-by-side test displays during the action test trials was.79 (*SD* =.20) and during the face test trials was.82 (*SD* =.14). These means did not differ from one another, $t(23) = 0.80$, $p > .1$, ES =.03, CI_{95} (mean difference) = − 0.10, 0.04.

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The PTLT to the novel faces or actions served as the primary dependent variable and was calculated in the same manner as for Experiment 1. These proportions are depicted in Figure 4, alongside the PTLTs from the 5.5-month-olds of the original study (Bahrick et al., 2002).

To determine whether infants showed significant discrimination of the faces and actions, the mean PTLTs were compared against the chance value of 50% in single-sample *t* tests. Results indicated that after the 1-min delay, infants showed a significant preference for the novel action, $t(23) = 2.50$, $p = .02$, ES =.21, $CI_{95} = 0.51, 0.64$ and a significant preference for the novel face, $t(23) = 2.77$, $p = .01$, ES =.25, $CI_{95} = 0.52, 0.64$. Thus, infants discriminated both the face and the action after a 1-min delay. Further analyses assessed the significance of the PTLTs on the first action trial and the first face trial against 50% to determine whether discrimination of faces and actions was evident initially or emerged later. Results indicated that infants showed a significant preference for the novel action, $t(23) = 2.74$, $p < .05$, ES =.25, $CI_{95} = 0.52, 0.68$, but not the novel face, $t(23) = 0.28$, $p > .10$, ES =.003, $CI_{95} = 0.40, 0.58$, during the first action and face test trials. Thus, at first older infants showed discrimination of actions but not faces, similar to the pattern shown by younger infants. Eventually, by the second test trial, infants showed discrimination of the faces, indexed by a novelty preference as well. This suggests that during the test phase, 7-month-olds required longer to exhibit evidence of face discrimination than action discrimination. The first face test trial may have provided additional exposure to the familiar face and a longer opportunity to compare and contrast the novel and familiar faces, promoting eventual discrimination.

The data were also examined at the individual subject level and evaluated with nonparametric tests. This pattern of results is similar to that of the parametric tests. For the action test trials, 18 of the 24 infants showed a novelty preference at the 1-min delay, $p < .05$ according to a binomial test. For the face test trials, only 16 of the 24 infants showed a novelty preference at the 1-min delay, $p > .10$ according to a binomial test; like the analyses of the first test trials, this indicates only that the discrimination of actions may be more consistent than the discrimination of faces at 7 months.

Finally, secondary tests were conducted to determine whether differences in novelty preferences were affected by the order of the test trials. A Test Order (AAFF vs. FFAA) × Test Type (face vs. action) mixed model ANOVA was conducted. There was no main effect of test order, $F(1, 22) = 0.36$, $p > .1$, ES =.02, no main effect of test type, $F(1, 22) = 0.01$, $p > .10$, ES =.001, and no interaction of test type and test order, $F(1, 22) = 0.01$, $p > .10$, ES =.001. Thus, there were no differences in discrimination ability based on order of test trials and no differences in discrimination ability for faces versus actions, and the test order effect did not differentially affect one test type more than the other.

In summary, the results indicate that on the basis of less than 160 s familiarization time, 7-month-old infants discriminate both faces and actions within the context of a dynamic event and remember them after a brief delay. However, detection of actions appears to occur earlier in processing time and to be more robust than detection of faces.

General Discussion

Bahrick et al. (2002) found that 5.5-month-old infants showed no evidence of discriminating the faces of women when they were engaged in dynamic activities; infants discriminated faces only when they were presented as static images. We proposed an attentional salience hypothesis suggesting that actions were especially salient to infants and recruited attention away from the face of the person engaged in the activity. Thus, infants' failure to discriminate faces did not reflect an inability to perceive dynamic faces in the context of activities; rather it reflected an attentional bias where the more salient actions were attended to earlier and longer than the

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faces. To address this hypothesis in the present studies, we predicted that if infant attention could be recruited to the faces in the context of actions, infants would then discriminate between them. Results support the attentional salience hypothesis and identify three conditions under which infants detect faces in the context of dynamic events: when they have sufficient familiarization time to encode both more and less salient aspects of the event (Experiment 1), when the face is seen in the context of different actions (Experiment 2), or following 6 weeks of additional experience with social events (Experiment 3).

Experiment 1 demonstrated that 5.5-month-old infants discriminated the faces of women engaged in dynamic events when given more exposure time to the events than infants in Bahrick et al. (2002; 320 s vs. 160 s). Following a 320-s familiarization phase (with a mean looking time of 253.73 s; *SD* = 32.31), infants showed a novelty preference for both the novel action and the novel face during test trials. Thus, although the actions were more salient to 5.5-month-old infants than the faces, once infants detected and processed the actions given the longer familiarization time, it appears that they then attended to the appearance of the faces engaged in the actions. Thus, actions were detected earlier in exploration or processing time than faces. Further, discrimination of the actions still appeared to be more robust than discrimination of the faces, as evidenced by the order effects found for face but not action tests.

Experiment 2 demonstrated that 5.5-month-old infants discriminated the face of a woman in the context of dynamic events when her face was invariant across multiple actions. Infants showed greater visual recovery to a change in face and action than to a change in the action alone. Consistent with infants' well-established tendency to abstract invariants across change (Gibson, 1969) and to categorize stimulation on the basis of similarity (e.g., Mandler, 1998; Needham, Dueker, & Lockhead, 2005; Quinn, 1987), infants abstracted the invariant face across different actions and generalized across changing actions. Thus, infants were capable of perceiving the identity of a dynamic face in the context of action when the task was structured to direct attention to the invariant face.

Finally, Experiment 3 demonstrated that 7-month-old infants discriminated the faces of women in dynamic events with half the available familiarization time required by 5.5-month-olds (160 s vs. 320 s). They showed a preference for both a novel action and a novel face during test trials on the basis of a 160-s exposure time (mean looking time of 121.93 s, *SD* = 19.89), whereas 5.5-month-olds showed no evidence of detecting a novel face on the basis of this exposure time (mean looking time of 152.50 s, *SD* = 15.76; Bahrick et al., 2002). Thus, older infants who have greater attentional flexibility, more rapid information processing, and many weeks of additional experience with faces and dynamic events are able to attend to both faces and actions in a shorter exposure time than 5.5-month-olds. However, even 7-month-old infants demonstrated better and earlier recognition of the actions than the faces. They showed a significant novelty preference on the first action test trial but not the first face test trial, suggesting that discrimination of faces required longer than discrimination of actions. Further, their discrimination of actions, but not faces, was significant in individual subject analyses. Therefore, even after infants could discriminate the faces in the context of actions, the actions still appeared to be more easily discriminated than the faces.

Together these findings suggest an attentional salience hierarchy where, in the context of viewing a single individual engaged in a single activity, the repetitive actions are more salient to young infants than the face of the individual engaged in the activity. This finding, that action is highly salient and object identity is less salient in early development, is consistent with the notion of conceptual primitives, where spatial relations and movement patterns are the focus of perceptual analysis in early development, forming the basis for concepts such as animacy and agency (e.g., Mandler, 1992).

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Furthermore, infants appear to detect and differentiate more salient information earlier in processing time; later in processing time, they shift the focus of their attention and differentiate less salient information. The salient actions were differentiated early in exploration; later in exploration, perceptual processing focused on the appearance of the individual engaged in the action. This processing sequence is consistent with Gibson's (1969) differentiation view of perceptual development and with a levels-of-processing framework (e.g., Adler et al., 1998; Craik & Lockhart, 1972). It should be noted, however, that our findings of greater attentional salience of actions over faces for young infants characterize perception of unfamiliar faces in potentially familiar, repetitive, everyday events, such as brushing teeth and blowing bubbles, and likely would not be generalizable to discrimination of familiar faces. Further, it is also likely that context plays an important role in attentional salience and that faces of individuals engaged in repetitive activities would become more salient to infants if facial identity were more relevant to the nature of the event or to the needs of the infant. For example, events involving two individuals where one had a positive valence (e.g., positive affect) and the other a more negative valence, or events where one individual was an agent of action and the other a recipient, would likely promote attention to the identity of the individuals (see Shuman & Bahrick, 2007; Vaillant-Molina & Bahrick, 2007, for examples). These are important questions that could be addressed in future research. Finally, it is clear from results of Experiment 2 that presentation format influences attentional salience. Invariant aspects of events become more salient, whereas aspects that vary become less salient. Thus, the opportunity to observe an unfamiliar individual engaged in a variety of activities increases attention to the face (invariant) and decreases attention to the specific nature of the activities that vary.

What does this series of studies tell us about early face perception? One of the most surprising aspects of the findings from Bahrick et al. (2002) and the current studies is that faces are not as salient to infants as is commonly assumed. Previous research investigating face perception has suggested that infants are highly attracted to faces and individuals are better at perceiving, discriminating, and recognizing faces than other stimuli (Goren et al., 1975; M. H. Johnson, Dziuraweic, Ellis, & Morton, 1991; Mondloch et al., 1999; Nelson, 2003; Simion et al., 1998; Slater & Quinn, 2001; Tanaka & Farah, 1993; Tanaka & Sengco, 1997; Thompson & Massaro, 1989; Ward, 1989; but see Diamond & Carey, 1986). Their enhanced perception has been attributed to the nature of the face (e.g., Easterbrook, Kisilevsky, Hains, & Muir, 1999), innate face perception modules (e.g., Slater & Quinn, 2001), areas of the brain specialized for face perception (e.g., M. H. Johnson & Morton, 1991; Kanwisher, Stanley, & Harris, 1999), and experience and perceptual learning (e.g., Nelson, 2003). The current studies, however, suggest that faces are not especially salient in the context of dynamic events. Young infants discriminate faces in static displays more easily than dynamic displays. Our findings suggest that this is because there is no attentional competition from salient actions.

Given that faces typically occur in the context of actions, our findings suggest that interpretations of existing research have overestimated infants' attention to and discrimination of faces in early development. Evidence of selective attention and superior discrimination of faces primarily rests on discrimination of static faces or schematic faces, decontextualized from the rich and complex movements they display that compete for attention (Bornstein & Arterberry, 2003; Bushnell et al., 1989; Cohen & Strauss, 1979; de Haan et al., 2001; Fagan, 1973; Field et al., 1984; Goren et al., 1975; M. H. Johnson et al., 1991; M. H. Johnson & Morton, 1991; Langlois & Roggmann, 1990; Pascalis et al., 1998, 2002; Pascalis et al., 1995; Rubenstein et al., 1999; Sai, 2005; Sangrigoli & de Schonen, 2004).

As such, it becomes important to ask: What naturalistic conditions might foster learning about the appearance of faces? Experiment 2 suggests that learning about faces is promoted when the person is invariant across a variety of different activities. This variability is typical of the infant's experience with adults. Even newborn discrimination of the face of the mother, which

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has been shown to require several hours of interaction with the mother (Bushnell, 2001), may in part be based on seeing her face across a variety of activities. Consistent with an expertise view of the development of face perception (e.g., Gauthier & Nelson, 2001), substantial experience with faces likely promotes more rapid perceptual differentiation in this domain. A comparison of Experiments 1 and 3 indicates that older infants differentiate actions and the faces of people engaged in activities more rapidly than younger infants. Perceptual differentiation is also likely to become more economical with development as infants become more skilled at detecting the distinctive features of the face. Another factor that may promote early face perception is prenatal exposure to the mother's voice, making her voice familiar at birth. Recent research suggests that neonatal experience of the mother's voice along with her face is necessary for newborn recognition of the mother's face (Sai, 2005). Finally, when a person is still and there is no competing stimulation, attention to the face is also promoted. Thus, a range of conditions likely promote attention to and differentiation of the face in early development. These include invariance of the face across different activities, extended bouts of exploration (allowing time for attention to the face following initial processing of more salient actions), association with a familiar voice, and exposure to a relatively still face.

By assessing face discrimination in more naturalistic contexts, the current studies indicate that infants do not attend to faces preferentially over dynamic aspects of stimulation. When viewing a person engaged in an activity, the face is not the most salient aspect of the dynamic event; rather, the action is more salient. From this view, one might be tempted to conclude that faces are not special in naturalistic events—rather, actions are special. This perspective, however, obscures the larger and more important questions regarding the nature and development of selective attention, the conditions that promote versus attenuate attention to different aspects of everyday events, and how this changes as a function of context. The present findings highlight the need for a better understanding of attentional hierarchies in the perception of everyday events and the importance of integrating our knowledge of face, voice, and action perception within this larger ecological framework.

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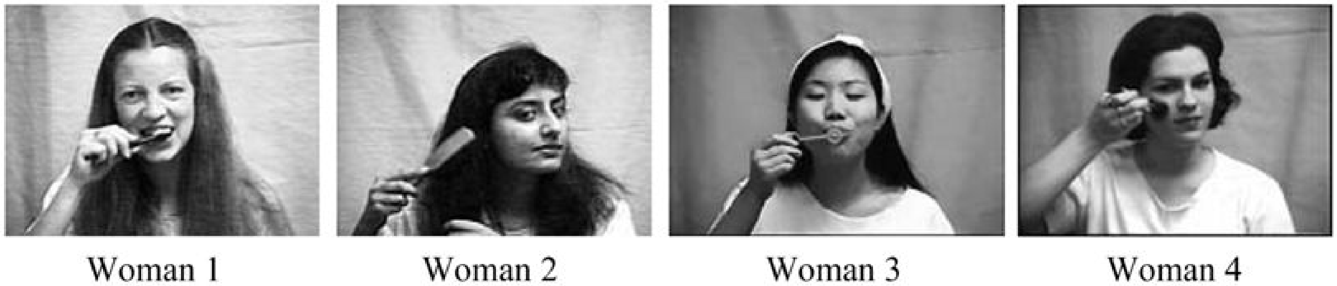

Figure 1.
Still images of activities. Women 1, 2, and 3 were used in Experiments 1 and 3; Women 1, 2, 3, and 4 were used in Experiment 2. All four individuals whose faces appear here were aware that their likenesses would be published. Photographs of Women 1, 2, and 3 are from "Attention and memory for faces and actions in infancy: The salience of actions over faces in dynamic events," by L. E. Bahrick, L. J. Gogate, and I. Ruiz, 2002, *Child Development, 73,* Figure 1, p. 1631. Copyright 2002 by Blackwell Publishing. Reprinted with permission.

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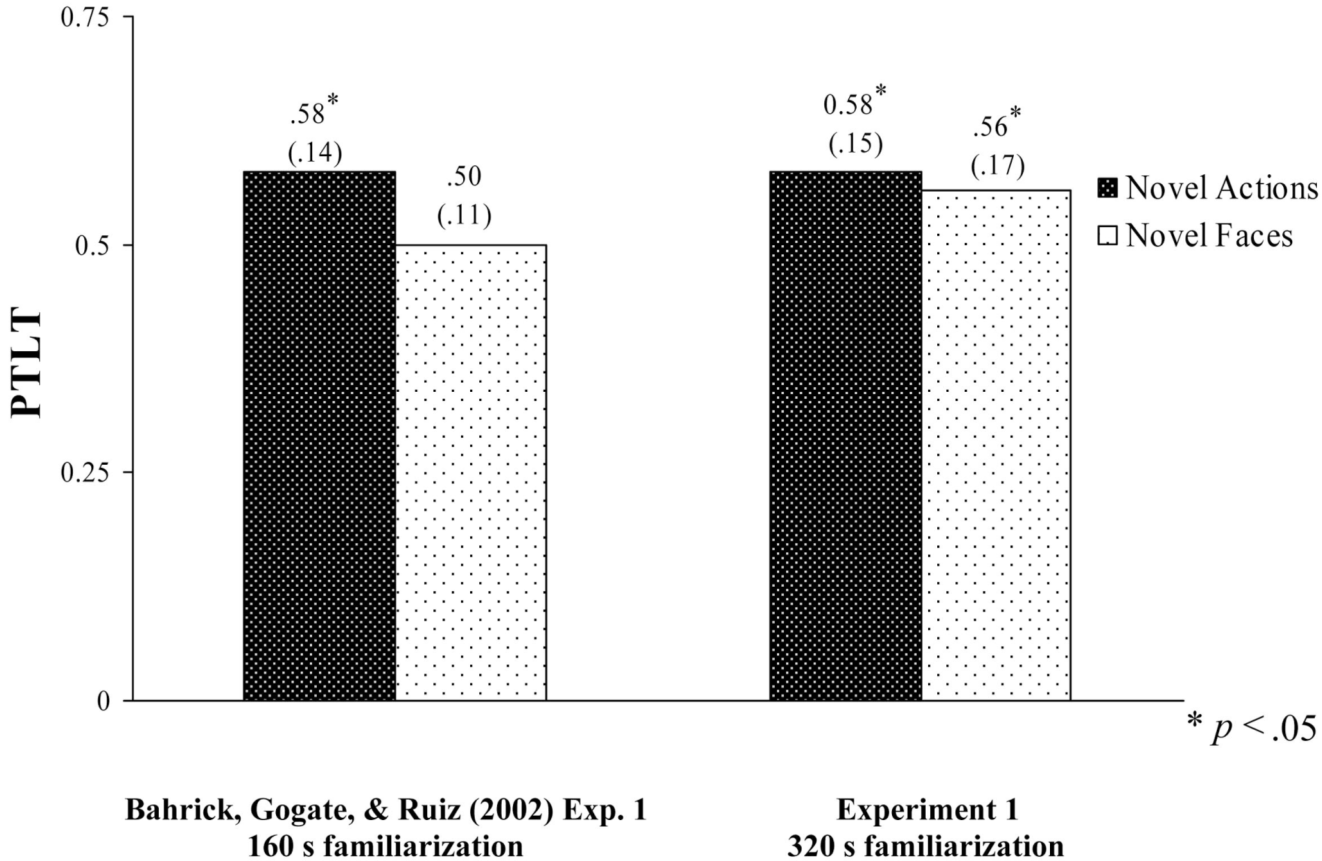

Figure 2.
Experiment 1: Proportions of total looking time (PTLT) and standard deviations (in parentheses) to novel actions and faces. Exp. = experiment.

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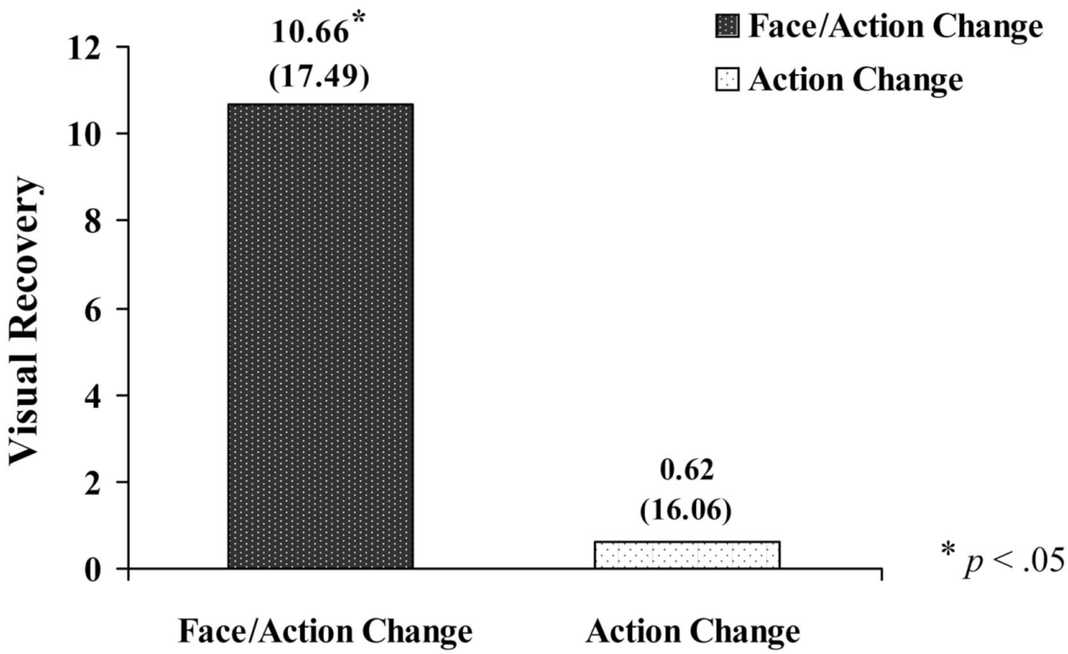

Figure 3.
Experiment 2: Mean visual recovery and standard deviation (in parentheses) to a change in face and action versus a change in action alone. Visual recovery is calculated as the difference between the average of the two posthabituation trials and the average of the two face/action test trials and the two action-alone test trials.

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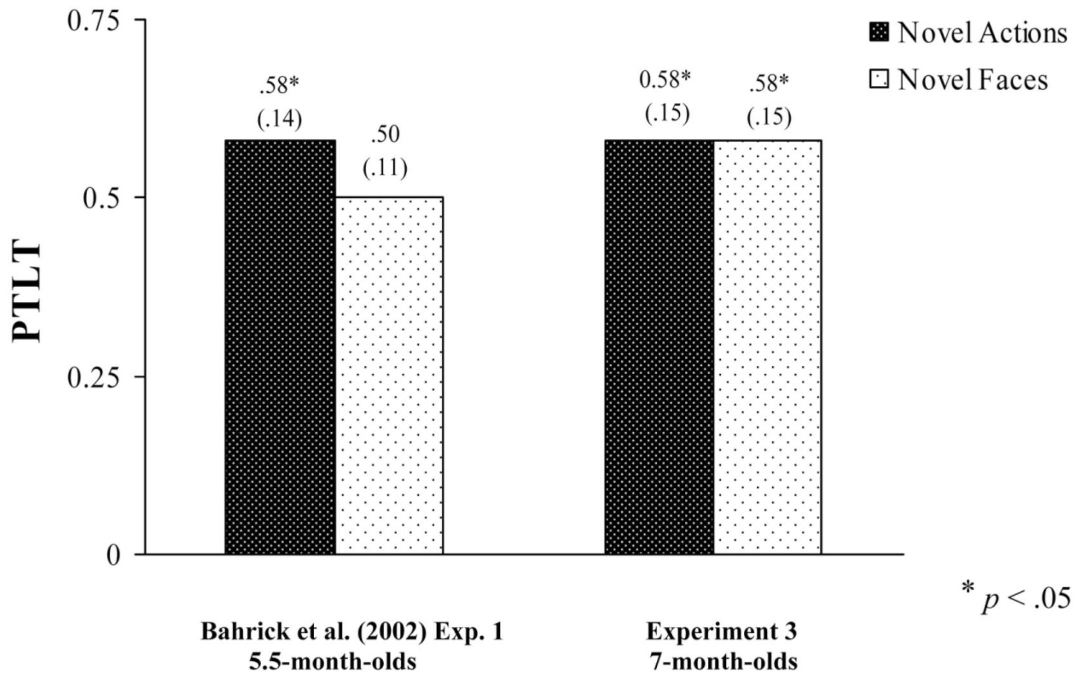

Figure 4.
Experiment 3: Proportions of total looking time (PTLT) and standard deviations (in parentheses) to novel actions and faces. Exp. = experiment.