

## The Relation of Affect to Attention and Learning in Infancy

*Susan A. Rose, Lorelle R. Futterweit, and Jeffery J. Jankowski*

The relation of positive affect to attention and learning was examined in 5-, 7-, and 9-month-olds ( $N = 84$ ). Affect and attention were assessed while the infants inspected a photograph. Affect was rated globally, for overall mood, and specifically, for amount of time smiling. Attention was indexed by the duration of the infant's longest (or peak) look, a measure previously linked to differential cognitive performance. At all ages, positive affect (shown by approximately half the infants) was associated with long look durations and slower learning, as assessed on a task in which infants learned to distinguish a familiar face from a series of novel faces. By contrast, neutral affect was associated with short looks and faster learning. Affect and look duration had synergistic effects, in that learning was faster than expected for infants who displayed both short looks and neutral affect. These findings are compatible with adult research that links positive affect to less analytical processing, and provide the first evidence that affect may be associated with the speed of processing differences implicated in short and long looking.

### INTRODUCTION

There is now considerable evidence that infants begin to build a rich cognitive repertoire within the 1st year of life—they form categories, abstract prototypes, fill in missing parts of figures, integrate information over space and time, and retain memories over periods of days and, in some cases, even months (Quinn & Eimas, 1996; Rose, 1988; Rose, Jankowski, & Senior, 1997; Rovee-Collier, 1997; Sherman, 1985; Skouteris, McKenzie, & Day, 1992). However, these intellectual feats remain poorly understood: Little is known about the factors that underlie infant cognition, account for individual differences, or propel developmental change. The present paper deals with two factors that we think may be implicated in many infant cognitive abilities: affect and attention.

Despite the contention of some theorists that affect is a fundamental motivator of cognitive growth (e.g., Piaget, 1962), the relation of affect to cognition as a topic of research interest has been relatively neglected for many decades. Over the past 10 years, however, a growing body of work with adults has emerged indicating that affect has pervasive effects on cognitive organization, attention, judgment, and memory (see Bower, 1981; Forgas, 1995). (Following Forgas [1995] we use the term affect to refer to both moods and emotions. Whereas moods are typically low-intensity, diffuse, and relatively enduring states, emotions tend to be intense, short-lived, and more likely to have a definite cause.) Of particular interest here are results from a number of mood-induction studies that indicate that participants in a happy or positive mood perform many tasks more poorly than participants with neutral or sad affect. Happy participants were found to make more global judgments and categorize

more broadly, whether the stimuli are social (Isen, Niedenthal, & Cantor, 1992) or nonsocial (Isen & Daubman, 1984). They also tend to be less critical and analytical in their thinking and are thus more easily persuaded by weak arguments (Bless, Mackie, & Schwarz, 1992; Mackie & Worth, 1989), and more likely to make inaccurate judgments, even in situations where there are objective criteria (Sinclair & Mark, 1995). In the Sinclair and Mark study, participants with statistical training were asked to estimate the magnitude and direction of correlation coefficients associated with several scatterplots. Participants who were in a positive or happy mood processed the material less systematically, took less care, and consequently made more errors than did participants in a neutral or negative mood. Given evidence that positive memories and thoughts are primed by a positive mood, it has been suggested that these positive thoughts compete for limited space in working memory, preempting the processing resources needed to perform the task at hand (see Mackie & Worth, 1989).

Although there are a number of studies of infant affect, most are concerned with charting the development of discrete emotions or emotional regulation (see Fox, 1994; Izard & Malatesta, 1987; Langsdorf, Izard, Rayias, & Hembree, 1983; Malatesta, Culver, Tesman, & Shepard, 1989). Only a handful has examined the relation between affect and cognition. These include several studies by Fagen and his colleagues, who have shown that negative affect impairs subsequent memory, in that infants who cry when learning a conditioned response show relatively poor retention (e.g., Fagen, Ohr, Fleckstein, & Ribner, 1985; Fagen,

Ohr, Singer, & Klein, 1989). Two studies have linked positive affect to poor learning. In one, Bloom and Capatides (1987) examined the relation between facial affect and the emergence of language in 12 children followed intensively from 9 to 24 months. Affect, monitored during play sessions, was coded for valence (neutral, negative, positive, mixed, equivocal) and frequency. The more frequently the children expressed positive affect, the older the age at which two major language milestones were achieved—the emergence of first words and the emergence of the vocabulary spurt typically seen during the 2nd year of life. By contrast, more frequent expression of neutral affect was associated with earlier achievement of these milestones. The authors suggest that neutral affect supports the reflective stance required for early language learning, whereas positive affect entails an evaluative stance that may compete for the cognitive resources needed for such learning (Bloom, 1990).

Support for this suggestion can be found in the results of a recent study by Nachmnan, Stern, and Best (1986), who examined the relation between positive affect and perceptual discrimination. In their study, 7-month-olds were familiarized to a puppet for 20 s and then received two 15 s test trials in which the familiar puppet was paired with a novel one. Positive affect (smiling) was induced in one group of infants during familiarization by having the puppet engage in rousing cycles of appearance and disappearance accompanied by a brightly intoned “peek-a-boo” at each reappearance. A neutral procedure, designed *not* to elicit smiling, was used for a second group; here the puppet moved back and forth, but always remaining in sight, and “peek-a-boo” was intoned in a monotonous cadence. The test phase was identical for both groups: The familiar puppet was paired with a new one—both were silent and neither moved. The results indicated that infants who smiled during familiarization (including those from the neutral group) showed a significant familiarity preference on test; by contrast, those who displayed neutral affect during familiarization showed significant novelty responses on test. The authors concluded that positive affect itself induces preference for familiarity. Given the growing evidence that familiarity preferences represent an earlier stage of processing than do novelty preferences, with familiarity preferences occurring when processing is incomplete and novelty responses when the process is complete (Hunter & Ames, 1988; Richards, 1997; Rose, Gottfried, Melloy-Carminar, & Bridger, 1982; Wagner & Sakovits, 1986), these findings also can be viewed as consistent with the adult work showing that positive affect is associated with less detailed, less accurate, or lower level processing.

In contrast to the paucity of work on the relation of affect to information processing, there stands a considerable body of work on the relation of attention to information processing (e.g., Lansink & Richards, 1997; Richards & Casey, 1991; Ruff, 1982; Ruff, Capozzoli, & Saltarelli, 1996; Ruff & Rothbart, 1996). The recent interest in attention has been fueled, in part, by studies showing that individual differences in measures based on infant visual attention correlate with measures of intellectual performance in later childhood (e.g., Rose & Feldman, 1995, 1997; Rose, Feldman, & Wallace, 1988, 1992; Rose, Feldman, Wallace, & Cohen, 1991; Rose, Feldman, Wallace, & McCarton, 1989, 1991; for summaries, see Colombo, 1993; McCall & Carriger, 1993). One aspect of attention that has received considerable examination in this regard is the distribution of looking time. In a series of studies, Colombo and his colleagues observed that some infants inspect a target with brief looks, whereas others typically favor longer looks (e.g., Colombo & Mitchell, 1990; Freeseaman, Colombo, & Coldren, 1993). Infants whose looks are relatively brief tend to distribute their attention more broadly (Bronson, 1991; Janowski & Rose, 1997) and process information more quickly. For example, in studies comparing global and local processing, short and long lookers (like adults) both showed a proclivity to process global aspects of the stimulus before local ones, but short lookers processed both aspects faster than did long lookers (Colombo, Mitchell, Coldren, & Freeseaman, 1991; Freeseaman et al., 1993). More recent work by this group of investigators suggests that short and long lookers may also attend differently to the stimulus, with short lookers favoring configural properties and long lookers favoring local properties (Colombo, Freeseaman, Coldren, & Frick, 1995; Colombo, Frick, Ryther, & Gifford, 1996; Frick & Colombo, 1996). In our own laboratory we have found that infants who are quickest at learning to discriminate a familiar stimulus from successively presented novel ones scan the targets with shorter looks than those who learn more slowly (Orlian & Rose, 1997). Thus, many of the qualitative and quantitative differences in the distribution of attention seem to have implications for infant information processing. Whereas the relation between affect and attention *per se* has not been widely studied, Ruff's work on focused attention, a state characterized by a serious, sober, or neutral facial expression, would suggest that positive affect is not conducive to efficient information processing (Ruff, 1982).

The present study extends the work on affect-cognition relations in several ways. First, relations are examined between infant affect and both attention and learning. The aspect of attention singled out for

study is look duration. Following Colombo (e.g., Colombo et al., 1991, 1995), a distinction is drawn between "short" and "long" looking infants. Second, the standard paired-comparison task used by Nachman et al. (1986) was modified so as to introduce a criterion for successful performance (Orlian & Rose, 1997): A familiar stimulus was repeatedly paired with new novel ones until infants systematically showed a preference for the novel member of the pair, indicating that they had learned which was familiar. Based on the adult work, and the two related infant studies, it was anticipated that positive affect would relate to longer look durations and to slower perceptual learning, that is, to slower attainment of the novelty preference criterion, whereas neutral affect would be associated with shorter look durations and faster learning. Positive affect itself was assessed in two ways: globally, in terms of overall mood, and specifically, in terms of the amount of time spent smiling. Assessments of affect and attention were made during a 20 s period in which the infant inspected a photograph, and these measures were then related to subsequent learning. Finally, infants of three different ages were studied (5, 7, and 9 months) in order to assess the generalizability and developmental nature of any relations found.

## METHOD

### Participants

The sample consisted of 84 term infants: 28 5-month-olds (18 males, 10 females); 28 7-month-olds (10 males, 18 females) and 28 9-month-olds (12 males, 16 females). The exact ages of infants in each group were 158, 213, and 277 days (with a range of  $\pm 10$  days at each age). Data from an additional 8, 7, and 7, infants were excluded at 5, 7, and 9 months due to fussiness/sleepiness ( $N = 6, 6, \text{ and } 5$ , respectively) or experimenter error ( $N = 2, 1, \text{ and } 1$ , respectively).

Participants were from predominately middle-class families: Maternal education averaged 14.7 years ( $SD = 2.1$ ), and paternal education averaged 15.1 years ( $SD = 2.5$ ). More than 75% of the parents had received education beyond high school: 33% had a technical degree, 28% a college degree, and 16% a graduate degree. In terms of ethnicity, the sample was about 61% Caucasian, 25% Hispanic, 4% African American, and 10% other. The educational background and ethnic composition of the sample were comparable for the three age groups.

### Design

There were two tasks: a Pretest followed by a Learning Task. In the Pretest, infants were given a pho-

tograph to look at, and the duration of their looks was used to classify them as either "short" or "long" lookers (e.g., Colombo et al., 1991; Freese et al., 1993). Their affect was classified as either predominately positive or neutral (and smiling was also coded). In the Learning Task, rate of learning was assessed using a procedure that combined aspects of both the habituation and the paired-comparison paradigms (see also Fantz, 1964; Orlian & Rose, 1997; Roder & Bushnell, 1987). In this task, infants were presented with a series of trials in which a single face (the familiar) was repeatedly paired with a series of novel ones. Trials continued until the infant either showed a stable preference for the novel member of the pair or the infant completed the entire series of 36 trials.

### Apparatus

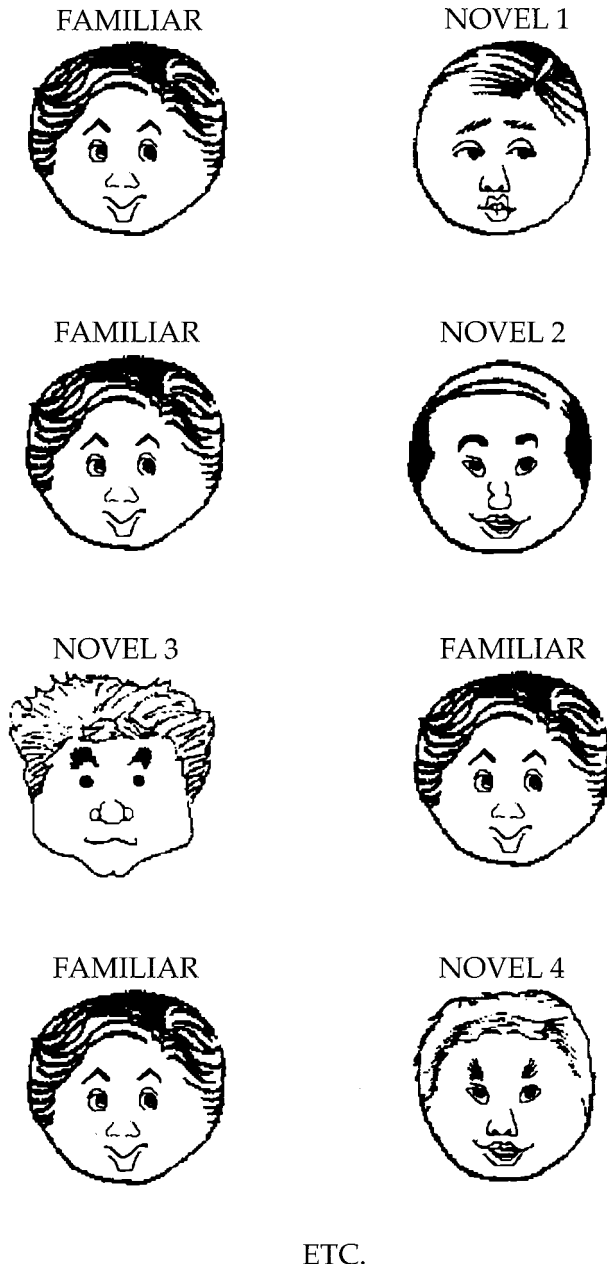
Testing took place in a three-sided booth that was constructed from panels of black fabric and measured 1.2 m on each side and 1.5 m across the front. Monitors of two Macintosh Classic computers were set into apertures cut into the middle panel. A Panasonic camera, centered in a 10 cm circular opening midway between the monitors, was used to videotape facial expressions. A peephole, centered 7 mm above the camera, was used for on-line recording of infant looks to either monitor. Two 40 watt lights, attached to the top of the enclosure and directed downward, illuminated the monitors and the infant's face.

### Stimuli

*Pretest.* The stimulus was a single color photograph that subtended an angle  $33^\circ$  wide and  $23^\circ$  high and depicted the face and shoulders of a dark-haired, 9-month-old Caucasian female; the pictured infant had a neutral but engaging expression and was photographed against a bright floral background.

*Learning task.* Stimuli consisted of 38 computer-generated black-and-white schematic faces. Each face was defined by its head (i.e., hair and facial contour) and an internal facial configuration made up of four features: brows, eyes, nose, and mouth (see Figure 1). Stimuli were approximately 9 cm high and 9 cm wide, each subtending a visual angle of about  $12.5^\circ$ . When paired, and presented on the two monitors, they were separated by a visual angle of about  $40^\circ$ .

Two different series were created (each to be used with half the infants); they differed only in the particular target that served as familiar. Thus, 2 of the 38 faces were designated as familiar; both were unique, in that the head as well as the internal features (brow, eyes, nose, and mouth) used to construct each were



**Figure 1** Sample presentation sequence for the learning task. On each trial the familiar was paired with a different novel face. Novel faces differed from the familiar in all internal features—brows, eyes, nose, and mouth—and in external features—hair and facial contour. Novel faces appeared randomly on either the left or right, but were never on the same side for more than two successive trials. Testing continued until infants reached criterion or completed 36 trials. Two comparable sets of stimuli were used.

not repeated in any of the novel faces in that series. The other 36 faces, designated as novel, were created from a pool consisting of 12 heads, 4 brows, 5 eyes, 5 noses, and 4 mouths. Among the novel faces, (1) no

head appeared more than once in any block of 12 trials, (2) each novel face differed from every other in at least two internal features, and (3) successively presented novel targets differed from one another in all features.

#### Procedure

*Pretest.* The infant was seated on the parent's lap, approximately 50 cm from the display panel. The photograph stimulus was presented directly in front of the two monitors (which were shielded from view). There was but a single trial, which began with the infant's first look to the photograph and ended when 20 s of looking had been accumulated (following Colombo et al., 1991, 1995). An observer, seated behind the testing booth, recorded fixations; the trial was timed, and looks recorded, using a Radio Shack TRS-80 computer. The infant's facial expressions were videotaped for later coding (a time code accurate to .1 s was electronically placed on the videotape).

*Learning task.* This task began immediately after the pretest. The two computer monitors were exposed, and there followed a series of trials in which the same schematic face was repeatedly paired with different novel faces. Each trial began with the first look to either face and ended after the infant had accumulated 4 s of looking to either or both of the targets. Novel faces appeared randomly on either side of the computer screen, with the stipulation that novel targets not appear on the same side on more than two successive trials. As determined by random assignment, half the infants of each age were tested with one of the familiarization faces; half with the other.

Testing continued for 36 trials or until criterion was reached, defined as a novelty response of 55% or greater on four out of five consecutive trials. To ensure there was active comparison of the targets, looks had to be directed to both members of the target pair for a trial to be included in the criterion run. Learning was indexed by the number of trials to reach criterion (those not reaching criterion received a score of 36).

The decision that individual novelty scores be 55% or greater for inclusion in the criterion run was somewhat arbitrary, but consistent with work showing that means of 54% or greater over a series of problems are reasonably sensitive and specific for the prediction of normal intelligence (Rose et al., 1988). Overall, mean scores in the criterion run typically average in the mid to upper 60s (e.g., Orlian & Rose, 1997), indicating that a decided preference for the novel stimulus has indeed been established.

All looks were recorded on a Macintosh Classic computer, which was programmed to provide a

record of the number and duration of looks for each trial. The computer also controlled the timing of each trial and determined when criterion was reached. The observer was unable to see the computer screens and thus was blind to the identity and left-right placement of novel and familiar stimuli. The reliability between pairs of observers, which is checked frequently in our laboratory, was high,  $r = .96$  to  $.98$ .

*Coding infant affect.* The principal measures of affect came from the Pretest. For the global coding, three categories of affective tone were identified: (1) positive, characterized by warm smiles, laughter, and/or pleasant vocalizations, (2) neutral/interest, characterized by mild, moderate or intense interest, but little or no smiling, and (3) negative, characterized by fretting, fussing, or whimpering. Two observers then independently viewed the records of all infants in real time, and each made a judgment as to the overall hedonic tone that predominated during the Pretest. This type of judgment was quite easy to make, and interobserver agreement was 100%.

The duration of smiling was coded on a separate pass through the videotape. Videotapes were first run in real time to identify infants who showed any smiling whatsoever. Then, for these infants, frame-by-frame analysis was used to code the exact duration of each smile (to .1 s). A smile was coded when the corners of the mouth were drawn back and the cheeks pushed up; brows remained in a normal or resting position. Coders were initially trained using the manual and training tapes from *The System for Identifying Affect Expressions by Holistic Judgments* (AFFEX; Izard, Dougherty, & Hembree, 1989).

Reliability was assessed by having naive coders independently code smiles for a random sample of 27 infants who showed at least some smiling. Coder agreement was assessed for (1) total duration of smiling in each 20 s period, (2) number of discrete smiles, and (3) duration of individual smiles. The reliability for the duration measure, calculated using the Pearson product-moment formula, was high,  $r = .97$ . To estimate rater reliability for identifying discrete smiles,

the number of agreements as to the occurrence of smiles was divided by agreements plus disagreements; the mean agreement was 94.7%. Finally, observer discrepancies in the duration of discrete smiles were examined and found to be minimal: 69.4% of the smiles scored by the two observers were within .2 s of each other, and no discrepancy was greater than 1.4 s. Overall, observer discrepancies in the duration of discrete smiles were quite small ( $M = .29$ ,  $SD = .30$ ).

## RESULTS

Preliminary analyses were carried out to assess the effects of familiarization stimulus and gender on the various measures of affect, attention, and learning. Because no consistent effects were found for either variable, the data are presented collapsed across both.

### Pretest

*Classifications by affect and peak look.* Infants were cross-classified by affect (global ratings) and attention on the Pretest. Positive and neutral affect ratings were assigned irrespective of age and attention. (Testing was discontinued during the pretest for those few infants with negative affect (i.e., crying or fussiness; see Participants section.) Attentional style, defined by peak look (the length of the longest look) during the 20 s inspecting the photo, took age into account. Infants whose peak looks fell below the median at each age were considered short lookers; those whose peaks fell above the median, long lookers. The median values for peak looks at 5-, 7-, and 9-months were 6.0 s ( $range = 1.9-11.5$ ), 5.7 s ( $range = 2.3-10.1$ ), and 4.9 s ( $range = 2.0-10.8$ ), respectively. The percentages of infants displaying positive affect at each of these ages was 42.9%, 57.1%, and 42.9%, respectively.

As can be seen in Table 1, short lookers predominated among those who had neutral affect and long lookers among those who had positive affect. This relation was evident at all three ages. Disregarding age, 67.5% of the 40 infants displaying positive affect

**Table 1** Distribution of Children by Affect and Attentional Style on the Pretest

	5-Month-Olds		7-Month-Olds		9-Month-Olds		Total Sample	
	Neutral	Positive	Neutral	Positive	Neutral	Positive	Neutral	Positive
Short looker	11	3	8	6	10	4	29	13
Long looker	5	9	4	10	6	8	15	27

*Note:* Short lookers—duration of peak look is below the age-specific median. Long lookers—Duration of peak look is above the age-specific median. Total  $N = 84$ .

**Table 2** Means for Measures of Smiling on the Pretest for Infants with Positive Affect

Measure	5-Month-Olds	7-Month-Olds	9-Month-Olds
<i>N</i>	12	16	12
Total time smiling (s)	8.6 (5.1)	6.9 (4.4)	6.0 (4.8)
Average smile duration (s)	3.0 (2.4)	1.8 (.8)	2.7 (1.1)
Number of smiles	3.6 (2.2)	3.8 (1.7)	2.3 (1.3)
Latency to first smile (s)	7.6 (7.4)	9.9 (9.9)	6.7 (8.0)

Note: Standard deviations are in parentheses.

were long lookers, and 65.9% of the 44 infants with neutral affect were short lookers,  $\chi^2(1, N = 84) = 9.36, p = .002$ .

**Smiling.** Smiling was rare in the 44 infants with neutral affect. There were only two or three in each age group who smiled at all, and their smiles were quite brief (generally totalling 1 s or less).

As might be expected, all 40 infants rated as positive in mood displayed some smiling during the 20 s they spent looking at the photograph (see Table 2). Overall, these infants spent about one-third of this time smiling. There were no significant age-related differences in any of the smiling measures, although there was a tendency for the mean duration of smiles and frequency of smiling to decrease as age increased,  $F_s(2, 37) = 2.51$  and  $2.53, p_s < .10$ .

**Visual attention.** Table 3 gives descriptive statistics for peak and two other measures of visual attention obtained during the Pretest, namely, average look (the mean duration of all looks) and number of looks (the number of discrete looks used to accumulate the

requisite 20 s of looking time). Each measure of attention was analyzed in a 2 (Affect: positive or neutral)  $\times$  3 (Age: 5, 7, or 9 months)  $\times$  2 (Attentional Style: long or short looker) analysis of variance (ANOVA).

There were significant main effects for age on all three measures—peak look, mean look, and number of looks— $F_s(2, 72) = 11.41, 4.72,$  and  $47.44,$  respectively,  $p_s < .05,$  and main effects for attentional style on the same dependent measures,  $F_s(1, 72) = 72.58, 43.15,$  and  $24.92, p_s < .001,$  respectively. These effects reflect the fact that peak look, mean look duration, and number of looks all decreased significantly with age and, of course, that looks were shorter and more numerous in short lookers than in long lookers. The effects for affect were significant for mean look duration and number of looks,  $F_s(1, 74) = 5.75$  and  $4.04, p_s < .05,$  respectively. Infants with neutral affect tended to have shorter (and hence more) looks than those with positive affect. There was only one significant interaction in any of these analyses: An interaction between attentional style and age for the number of looks,  $F(1, 74) = 3.47, p < .05,$  indicating that the major increase over age in number of looks occurred earlier in long lookers (7 months) than in short lookers (9 months).

Overall then, affect and attention were related. Looks were briefer and more numerous in infants with neutral affect, and correspondingly, longer and less numerous in infants with positive affect. Also, older infants had more numerous and shorter looks, supporting contentions that the attentional strategies associated with neutral affect are more mature than those associated with positive affect.

**Table 3** Means for Measures of Attention on the Pretest

Measures	Neutral Affect		Positive Affect		Total Sample
	Short Looker	Long Looker	Short Looker	Long Looker	
<b>5-Month-Olds</b>					
Peak look(s)	4.0 (1.4)	8.3 (2.3)	4.5 (.8)	9.1 (3.1)	6.4 (3.2)
Average look (s)	1.9 (.5)	3.6 (.9)	2.4 (.5)	5.1 (2.1)	3.3 (1.9)
Number of looks	11.0 (2.9)	5.8 (1.3)	8.7 (2.1)	4.3 (1.2)	7.7 (3.6)
<b>7-Month-Olds</b>					
Peak look(s)	3.8 (1.0)	6.4 (.4)	4.7 (1.0)	7.4 (1.6)	5.6 (1.9)
Average look (s)	2.1 (.8)	2.9 (1.4)	2.4 (.5)	3.5 (1.8)	2.8 (1.4)
Number of looks	10.8 (4.5)	9.8 (8.2)	8.7 (2.0)	7.2 (3.3)	8.9 (4.4)
<b>9-Month-Olds</b>					
Peak look (s)	3.5 (.8)	6.5 (1.5)	3.4 (.7)	6.7 (2.2)	5.1 (2.1)
Average look (s)	1.6 (.5)	2.9 (.9)	1.6 (.3)	3.4 (1.5)	2.4 (1.2)
Number of looks	13.8 (4.4)	7.7 (2.9)	13.0 (2.4)	6.8 (2.6)	10.4 (4.6)

Note: Standard deviations are in parentheses.

### Relation of Affect and Attention to Learning

Table 4 shows several aspects of performance on the learning task for infants at 5-, 7-, and 9-months cross-classified by affect and attentional strategy. Trials to criterion, the principal measure of learning, was analyzed in a 2 (Affect: positive or neutral)  $\times$  3 (Age: 5-, 7-, or 9-months)  $\times$  2 (Attentional style: long or short looker) ANOVA. There were significant main effects for all factors, indicating that faster learning was associated with neutral affect, older age, and short lookers,  $F(1, 72) = 13.4, p < .001, F(2, 72) = 4.01, p < .05,$  and  $F(1, 72) = 8.34, p < .01,$  respectively. Importantly, there was also a significant Affect  $\times$  Attentional style interaction, indicating that the faster learning of short lookers was enhanced among those with neutral affect,  $F(1, 72) = 8.04, p < .01.$  A complementary analysis of the percentage of infants in each group who actually reached criterion yielded similar results: 93.1% of the short lookers with neutral affect reached criterion, compared with only 53.3% of short lookers with positive affect, and about 38% of either group of long-lookers,  $\chi^2(3, N = 84) = 21.87, p < .001.$  These results suggest that attentional style and affect have a synergistic effect on performance. (For the interested reader, bivariate correlations for the major relations, partialled for age, are presented in the Appendix.)

Analyses of the ancillary measures associated with

the learning task (see Table 4) indicate that the average duration of looks decreased as age increased,  $F(2, 72) = 11.88, p < .001,$  paralleling results seen in the Pretest. The average duration of looks during learning was also shorter in infants with neutral affect, although this effect was only marginally significant,  $F(1, 72) = 3.49, p < .07.$

The mean duration of smiling during the learning phase was analyzed in a 2 (Affect: positive or neutral)  $\times$  3 (Age: 5-, 7-, or 9-months)  $\times$  2 (Attentional style: long or short looker) ANOVA. The only effect approaching significance was that for affect,  $F(1, 72) = 2.67, p = .10,$  indicating that infants with positive affect on Pretest smiled more during learning than those with neutral affect. Infants with positive affect also smiled more frequently ( $N = 19$  versus 9),  $\chi^2(1, N = 84) = 6.90, p < .01.$  However, smiles during learning were typically briefer and more fleeting than those on the Pretest.

*Regression analysis.* In the ANOVA, affect and peak look were used as grouping variables. However, if affect and peak look are treated as continuous variables, we can use simultaneous multiple regression to determine the extent to which each is associated with individual differences in speed of learning. In this regression, age, total time spent smiling at the photograph on the pretest, and peak look during the pretest were entered simultaneously in the equation; in addition, an interaction term was included to determine

**Table 4** Performance on the Learning Task

Measures	Neutral Affect		Positive Affect		Total Sample
	Short Looker	Long Looker	Short Looker	Long Looker	
<b>5-Month-Olds</b>					
Trials to criterion	14.2 (10.4)	36.0 (.0)	32.7 (5.8)	33.3 (5.9)	26.2 (12.3)
Reached criterion, <i>N</i> (%)	10 (91%)	0	1 (34%)	2 (22%)	13 (46%)
Average look	1.4 (.3)	1.9 (.5)	1.8 (.7)	2.0 (.3)	1.8 (.5)
Smilers, <i>N</i> (%)	1 (9%)	2 (40%)	1 (34%)	2 (22%)	6 (21%)
Average smile	.9 (.0)	.1 (.1)	.4 (.0)	.1 (.1)	1.0 (.0)
<b>7-Month-Olds</b>					
Trials to criterion	15.0 (10.5)	21.8 (11.2)	32.0 (9.8)	27.3 (12.5)	24.0 (12.4)
Reached criterion, <i>N</i> (%)	7 (88%)	3 (75%)	1 (17%)	4 (40%)	15 (54%)
Average look	1.4 (.4)	1.9 (.5)	1.6 (.4)	1.7 (.6)	1.6 (.5)
Smilers, <i>N</i> (%)	2 (25%)	1 (25%)	3 (50%)	6 (60%)	12 (43%)
Average smile	.3 (.1)	.1 (.1)	.4 (.0)	.1 (.1)	1.0 (.0)
<b>9-Month-Olds</b>					
Trials to criterion	13.9 (6.2)	23.5 (7.5)	21.8 (10.7)	26.1 (11.7)	20.6 (10.0)
Reached criterion, <i>N</i> (%)	10 (100%)	5 (83%)	3 (75%)	4 (50%)	22 (79%)
Average look	1.3 (6.2)	1.4 (.2)	1.2 (.1)	1.4 (.2)	1.3 (.2)
Smilers, <i>N</i> (%)	0	3 (50%)	2 (50%)	5 (63%)	10 (36%)
Average smile	—	.5 (.5)	1.3 (1.8)	.6 (.9)	1.0 (.0)

*Note:* The values for trials to criterion, average look, and average smile are means (SD). Average look and smile are measured in seconds.

**Table 5** Simultaneous Multiple Regression Predicting Learning from Age and Pretest Measures Considered as Continuous Variables

Predictor	Independent Contribution of Predictor ( $sr^2$ )	<i>t</i>	<i>p</i>
Age	.01	1.17	.245
Total smiling	.14	3.79	.000
Peak look	.09	3.16	.002
Total smiling $\times$ peak look	.06	2.65	.010
$R^2 = .54$ $F(4, 79) = 8.05$ , $p < .001$			

Note: The squared semipartial correlation ( $sr^2$ ) gives the unique contribution of each measure independent of all the others.

the degree to which the synergy between smiling and peak look also contributed. The squared semipartial correlations ( $sr^2$ ) given in Table 5 indicate the percentage of variance in learning accounted for by each measure independently of all others. They show that smiling, peak, and their interaction all made independent contributions, with each accounting for anywhere from 6% to 14% of the variance in learning. Taken together, these variables accounted for more than half (54%) the variation in learning speed among infants.

## DISCUSSION

The results of the present study provide evidence that infants' affect relates to their attention and learning. Infants who displayed positive affect on the Pretest—those who smiled at the photograph—inspected the photo with long looks, a style associated with younger age and immature patterns of information processing. By contrast, infants who exhibited sober or serious facial expressions tended to have shorter, more frequent looks, a style associated with older age and better information processing. Affect and attentional style both related to speed of learning. Infants with positive affect were slower to learn than those with neutral affect. Similarly, long lookers were slower to learn than short lookers. Moreover, affect and attentional style had synergistic effects, so that short lookers with neutral affect learned more quickly and were more likely to reach criterion than could be expected based on the individual effects of attentional style and affect. The relations among affect, attention, and learning were similar at all three ages—5, 7, and 9 months. Individual differences in affect and attention, taken together, accounted for more than one-half the variance in speed of learning.

There are several noteworthy aspects of the present

findings. First, the findings of significantly shorter peak looks and mean duration of looks at older ages support Colombo's contentions that the short-looking style is a more mature one (e.g., Colombo et al., 1991, 1995). Second, the findings extend this work by relating attentional style directly to learning speed. Third, they replicate previous findings from our own laboratory relating look duration to novelty scores (Janowski & Rose, 1997) and speed of learning (Orlian & Rose, 1997). Fourth, they provide the first evidence that attention, as reflected in look duration, has a substantial association with affect. (The correlation between affect and peak look, considered as a continuous variable, was  $r(83) = .35$ ,  $p < .01$ .) Fifth, they suggest that affect and attention are separate, independent dimensions of individuality, that can have synergistic effects on learning. Sixth, given the relation of initial affect to subsequent learning, they suggest, in line with adult work, that initial mood has a relatively enduring effect. Seventh, the relation of affect to learning supports Ruff's (1982) work on focused attention, an attentional state characterized by a sober, interested, or neutral facial expression and associated with superior processing.

There were no significant developmental effects associated with affect. Indeed, with the exception of a nonsignificant tendency for the mean duration and frequency of smiling to decrease with age, the incidence, intensity, and correlates of positive affect were remarkably similar across age. By contrast, both attention and learning differed as a function of age. Over age, the mean duration of looks decreased, and their frequency increased, a finding compatible with the literature (e.g., Colombo, 1993; Colombo et al., 1991) and with the contention that short looks reflect a more mature processing style. There was also an age-related improvement in learning, although the task proved to be relatively difficult, with only 46.4%, 53.6%, and 78.5% of the 5-, 7-, and 9-month-olds reaching criterion. The relative difficulty is similar to that found by Orlian and Rose (1997), where only 61.7% of a group comprised of 5½- to 7½-month-olds reached criterion on a variant of the task designed to be somewhat easier. It should be noted that the relation between peak look on pretest and learning present here was not found in the Orlian and Rose study. We think its absence there was probably related to the greater inclusiveness of infants of different ages in a single group. Relations with peak may be more conspicuous when, as in the present study, the age grouping is more tightly constrained (here, infants were all within 10 days of their target age), a conjecture in line with the sharp decrease in peak found with increasing age.

Although positive affect clearly had a limiting effect on cognitive processing, the mechanisms underlying this effect are not completely understood, even in adults (Forgas, 1995). Given that individuals with positive affect are likely to have increased arousal levels, one possibility is that it is high arousal rather than positive affect that impedes performance. Although high arousal (provided it is not too high) can facilitate adult's performance on simple tasks, it tends to inhibit their performance on complex tasks (Zajonc, 1980). Parallel findings have been reported in infancy, in that infants in high arousal states attend preferentially to simple stimuli whereas those in low arousal states prefer more complex stimuli (Gardner, Lewkowicz, Rose, & Karmel, 1986). Although affect and arousal are often confounded, Sinclair and Mark (1995) recently sought to assess their independent effects by manipulating each factorially. Their results show that, regardless of arousal level, positive mood led to less accurate processing than did negative mood. However, the effect of arousal on accuracy was in the expected direction, and there is some question about the adequacy of the assessment of arousal.

Another possibility is that infants experiencing positive affect are more likely to direct attention to the affective features or dimensions of the stimuli than are neutral-affect infants. Halberstadt and Niedenthal (1997) found that, when adults were asked to judge facial similarity, those who themselves were in emotional states (happy or sad) gave greatest weight to the emotional dimension of faces. By contrast, neutral-emotion participants gave greatest weight to other dimensions of the faces. If happy infants have a similar proclivity to respond to the affective tone of facial expressions, their performance on the learning task could have suffered simply because the familiar and novel faces tended to be similar (neutral) in this regard. Such a motivational explanation might be assessed in future work by making the affective dimension relevant for the discrimination. If affective states enhance attention to affective factors, then the performance of infants with positive affect should improve.

The expressions of positive and neutral affect evidenced by adults and infants may reflect a temporary state, or a more basic temperamental trait (i.e., a relatively enduring, biologically based characteristic of the individual). In most of the adult studies, mood has been induced experimentally and treated as a state; individual differences in personality have been generally ignored as have been potential interactions between state and trait factors. In the infant work, on the other hand, affect-related effects have been linked to both state and traits. In the Nachman, Stern, and Best (1986) study, induced and spontaneous expressions of

affect had similar effects on performance, and in the work of Bloom (1990), differences in emotional tone associated with early language learning appeared to reflect relatively stable characteristics of the infant. Unfortunately, we did not assess the consistency of affect expression, either across pictures or across time, so we do not know whether the poorer learning we observed in infants showing positive affect is a function of momentary, situational factors, or some more persistent temperamental tendency. Further work is needed to disentangle the role of state and trait.

It should be noted that, in some situations, positive affect actually seems to facilitate performance in adults. Notably, positive affect has been associated with greater creativity (e.g., Isen & Daubman, 1984). Indeed, positive mood is associated with an increased likelihood of making remote connections, giving more unusual associations to neutral words, and more inclusive categorizations. In short, positive moods may promote more expansive thinking, less focused attention, increased level and breadth of cognitive search, all of which can lead to more creative problem solving (see Isen & Daubman, 1984; Isen et al., 1992).

Overall, the results of the present study indicate that, in the 1st year of life, infants who spontaneously displayed positive affect while looking at the photo of another infant also had longer looks, an aspect of visual attention previously found to be associated with poorer processing. Infants who displayed positive affect took more trials to reach criterion on a subsequent perceptual learning task than those with neutral affect, and more of them failed to reach criterion at all. Learning was faster among infants with neutral affect and short looks than expected from the individual effects of affect and attentional style, indicating that affect and attention have synergistic effects on learning.

## ACKNOWLEDGMENTS

This research was supported in part by a Social and Behavioral Sciences Research Grant from the March of Dimes Birth Defects Foundation, by Grants HD 13810 and HD 01799 from the National Institutes of Health, and by postdoctoral Fellowships (HD 07384) to Lorelle Futterweit and Jeffery Jankowski. We thank Frances Goldenberg, Sharon Frisch, Bena Brandwein, and Michelle Brown for their help in testing infants and scoring data, Karen Adolph for help in judging infant affect, and Judith F. Feldman for her careful reading and insightful comments on an earlier version of the manuscript.

## ADDRESSES AND AFFILIATIONS

Corresponding author: Susan A. Rose, Departments of Pediatrics and Psychiatry, Kennedy Center, Albert Einstein College of Medicine, 1300 Morris Park Avenue, Bronx, NY 10461; e-mail: srose@aecom.yu.edu. Lorelle R. Futterweit and Jeffery J. Jankowski are also at the Albert Einstein College of Medicine.

## APPENDIX

Correlations among Principal Measures, Partialled for Age ( $N = 84$ )

Measures	2	3	4	5	6	7	8	9
Pretest								
1. Neutral/positive affect	.74	.73	.33	.35	.37	.45	.29	.20
2. Total smiling		.80	.30	.38	.38	.40	.19	.22
3. Average smile			.40	.57	.60	.40	.20	.16
4. Short/long looking				.74	.58	.42	.26	.10
5. Peak look					.76	.33	.23	.08
6. Average look						.24	.17	.14
Learning Task								
7. Trials to criterion							.48	-.04
8. Average look								-.12
9. Average smile								

Note: Neutral/positive affect is scored dichotomously: neutral = 1, positive = 2. Short/long looking is scored dichotomously: short = 1, long = 2.

## REFERENCES

- Bless, H., Mackie, D. M., & Schwarz, N. (1992). Mood effects on attitude judgments: Independent effects of mood before and after message elaboration. *Journal of Personality and Social Psychology, 63*, 585–595.
- Bloom, L. (1990). Developments in expression: Affect and speech. In N. Stein, B. Leventhal, & T. Trabasso (Eds.), *Psychological and biological approaches to emotion* (pp. 215–245). Hillsdale, NJ: Erlbaum.
- Bloom, L., & Capatides, J. (1987). Expression of affect and the emergence of language. *Child Development, 58*, 1513–1522.
- Bower, G. H. (1981). Mood and memory. *American Psychologist, 36*, 129–148.
- Bronson, G. W. (1991). Individual differences in rate of visual encoding. *Child Development, 62*, 44–54.
- Colombo, J. (1993). *Infant cognition: Predicting later intellectual functioning*. Newbury Park, CA: Sage.
- Colombo, J., Freeseaman, L. J., Coldren, J. T., & Frick, J. E. (1995). Individual differences in infant fixation duration: Dominance of global versus local stimulus properties. *Cognitive Development, 10*, 271–285.
- Colombo, J., Frick, J. E., Ryther, J. S., & Gifford, J. J. (1996). Four-month-olds recognition of complementary-contour forms. *Infant Behavior and Development, 19*, 113–119.
- Colombo, J., & Mitchell, D. W. (1990). Individual differences in early visual attention: Fixation time and information processing. In J. Colombo & J. Fagen (Eds.), *Individual differences in infancy: Reliability, stability, prediction* (pp. 193–228). Hillsdale, NJ: Erlbaum.
- Colombo, J., Mitchell, D. W., Coldren, J. T., & Freeseaman, L. J. (1991). Individual differences in infant visual attention: Are short lookers faster processors or feature processors? *Child Development, 62*, 1247–1257.
- Fagen, J. W., Ohr, P. S., Fleckstein, L. K., & Ribner, D. (1985). The effect of crying on long-term memory in infancy. *Child Development, 56*, 1584–1592.
- Fagen, J. W., Ohr, P. S., Singer, J. M., & Klein, S. J. (1989). Crying and retrograde amnesia in young infants. *Infant Behavior and Development, 12*, 13–24.
- Fantz, R. L. (1964). Visual experience in infants: Decreased attention to familiar patterns relative to novel ones. *Science, 146*, 668–670.
- Forgas, J. P. (1995). Mood and judgment: The affect infusion model (AIM). *Psychological Bulletin, 117*, 39–66.
- Fox, N. (1994). The development of emotion regulation: Biological and behavioral considerations. *Monographs of the Society for Research in Child Development, 59*, No. 240.
- Freeseaman, L. J., Colombo, J., & Coldren, J. T. (1993). Individual differences in infant visual attention: Four-month-olds' discrimination and generalization of global and local stimulus properties. *Child Development, 64*, 1191–1203.
- Frick, J. E., & Colombo, J. (1996). Individual differences in infant visual attention: Recognition of degraded visual forms by four-month-olds. *Child Development, 67*, 188–204.
- Gardner, J. M., Lewkowicz, D. J., Rose, S. A., & Karmel, B. Z. (1986). Effects of visual and auditory stimulation on subsequent visual preferences in neonates. *International Journal of Behavioral Development, 9*, 251–263.
- Halberstadt, J. B., & Niedenthal, P. M. (1997). Emotional state and the use of stimulus dimensions in judgment. *Journal of Personality and Social Psychology, 72*, 1017–1033.
- Hunter, M. A., & Ames, E. W. (1988). A multifactor model of infant preferences for novel and familiar stimuli. In C. K. Rovee-Collier & L. P. Lipsitt (Eds.), *Advances in Infancy Research* (Vol. 5, pp. 70–95). Norwood, NJ: Ablex.
- Isen, A. M., & Daubman, K. A. (1984). The influence of affect on categorization. *Journal of Personality and Social Psychology, 47*, 1206–1217.
- Isen, A. M., Niedenthal, P. M., & Cantor (1992). An influence of positive affect on social categorization. *Motivation and Emotion, 16*, 65–78.
- Izard, C. E., Dougherty, L. M., & Hembree, E. A. (1989). *A system for identifying affect expressions by holistic judgments (Affex)*. Newark, DE: Instructional Resources Center, University of Delaware.
- Izard, C. E., & Malatesta, C. Z. (1987). Perspectives on emotional development I: Differential emotions: Theory of early emotional development. In J. D. Osofsky (Ed.), *Handbook of infant development* (2nd ed., pp. 494–554). New York: Wiley.

- Jankowski, J. J., & Rose, S. A. (1997). The distribution of visual attention in infants. *Journal of Experimental Child Psychology, 65*, 127–140.
- Langsdorf, P., Izard, C., Rayias, M., & Hembree, C. (1983). Interest expression, visual fixation, and heart rate changes in 2- to 8-month old infants. *Developmental Psychology, 19*, 375–386.
- Lansink, J. M., & Richards, J. E. (1997). Heart rate and behavioral measures of attention in six-, nine-, and twelve-month-old infants during object exploration. *Child Development, 68*, 610–620.
- Mackie, D. M., & Worth, L. T. (1989). Processing deficits and the mediation of positive affect in persuasion. *Journal of Personality and Social Psychology, 57*, 27–40.
- Malatesta, C. Z., Culver, C., Tesman, J. R., & Shepard, B. (1989). The development of emotion expression during the first two years of life. *Monographs of the Society for Research in Child Development, 54*, No. 219.
- McCall, R. B., & Carriger, M. S. (1993). A meta-analysis of infant habituation and recognition memory performance as predictors of later IQ. *Child Development, 64*, 57–79.
- Nachman, P. A., Stern, D. N., & Best, C. (1986). Affective reactions to stimuli and infants' preference for novelty and familiarity. *Journal of the American Academy of Child Psychiatry, 25*, 801–804.
- Orlian, E. K., & Rose, S. A. (1997). Speed vs. thoroughness in infant visual information processing. *Infant Behavior and Development, 20*, 371–381.
- Piaget, J. (1962). The relation of affectivity to intelligence in the moral development of the child. *Bulletin of the Menninger Clinic, 26*, 129–137.
- Quinn, P. C., & Eimas, P. D. (1996). Perceptual organization and categorization in young infants. In C. Rovee-Collier & L. P. Lipsitt (Eds.), *Advances in Infancy Research* (Vol. 10, pp. 1–36). Norwood, NJ: Ablex.
- Richards, J. E. (1997). Effects of attention on infants' preference for briefly exposed visual stimuli in the paired-comparison recognition-memory paradigm. *Developmental Psychology, 33*, 22–31.
- Richards, J. E., & Casey, B. J. (1991). Heart rate variability during attention phases in young infants. *Psychophysiology, 28*, 43–53.
- Roder, B. J., & Bushnell, E. W. (1987, April). *The time-course of constructing a schema for a visual stimulus during infancy*. Paper presented at the biennial meeting of the Society for Research in Child Development, Baltimore, MD.
- Rose, S. A. (1988). Shape retention in infancy: Visual integration of sequential information. *Child Development, 59*, 1161–1176.
- Rose, S. A., & Feldman, J. F. (1995). Prediction of IQ and specific cognitive abilities at 11 years from infancy measures. *Developmental Psychology, 31*, 685–696.
- Rose, S. A., & Feldman, J. F. (1997). Memory and speed: Their role in the relation of infant information processing to later IQ. *Child Development, 68*, 630–641.
- Rose, S. A., Feldman, J. F., & Wallace, I. F. (1988). Individual differences in infant's information processing: Reliability, stability, and prediction. *Child Development, 59*, 1177–1197.
- Rose, S. A., Feldman, J. F., & Wallace, I. F. (1992). Infant information processing in relation to six-year cognitive outcomes. *Child Development, 63*, 1126–1141.
- Rose, S. A., Feldman, J. F., Wallace, I. F., & Cohen, P. (1991). Language: A partial link between infant attention and later intelligence. *Developmental Psychology, 27*, 798–805.
- Rose, S. A., Feldman, J. F., Wallace, I. F., & McCarton, C. (1989). Infant visual attention: Relation to birth status and developmental outcome during the first 5 years. *Developmental Psychology, 25*, 560–575.
- Rose, S. A., Feldman, J. F., Wallace, I. F., & McCarton, C. (1991). Information processing at 1 year: Relation to birth status and developmental outcome during the first five years. *Developmental Psychology, 27*, 723–737.
- Rose, S. A., Gottfried, A. W., Mello-Carminar, P. M., & Bridger, W. H. (1982). Familiarity and novelty preferences in infant recognition memory: Implications for information processing. *Developmental Psychology, 18*, 704–713.
- Rose, S. A., Jankowski, J. J., & Senior, G. J. (1997). Infants' recognition of contour-deleted figures. *Journal of Experimental Psychology: Human Perception and Performance, 23*, 1206–1216.
- Rovee-Collier, C. (1997). Dissociations in infant memory: Rethinking the development of implicit and explicit memory. *Psychological Review, 104*, 467–498.
- Ruff, H. A. (1982). Role of manipulation in infants' responses to invariant properties of objects. *Developmental Psychology, 18*, 682–691.
- Ruff, H. A., Capozzoli, M., & Salterelli, L. (1996). Focused attention and distractibility in 10-month-old infants. *Infant Behavior and Development, 19*, 281–293.
- Ruff, H. A., & Rothbart, M. K. (1996). *Attention in early development: Themes and variations*. New York: Oxford University Press.
- Sherman, T. (1985). Categorization skills in infants. *Child Development, 56*, 1561–1573.
- Sinclair, R. C., & Mark, M. M. (1995). The effects of mood state on judgmental accuracy: Processing strategy as a mechanism. *Cognition and Emotion, 9*, 417–438.
- Skouteris, H., McKenzie, B. E., & Day, R. H. (1992). Integration of sequential information for shape perception by infants: A developmental study. *Child Development, 63*, 1164–1176.
- Wagner, S. H., & Sakovits, L. J. (1986). A process analysis of infant visual and cross-modal recognition memory: Implications for an amodal code. In L. P. Lipsitt & C. K. Rovee-Collier (Eds.), *Advances in infancy research* (Vol. 4, pp. 195–217). Norwood, NJ: Ablex.
- Zajonc, R. B. (1980). Feeling and thinking: Preferences need no inferences. *American Psychologist, 35*, 151–175.