

RESEARCH ARTICLE

Infants' Preferences for Familiarity and
Novelty During the Course of
Visual Processing

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At 4½ months, infants were shown a series of brief choice trials between a stimulus that always remained the same and another that was different on every trial. The point when a consistent preference for the novel stimulus commenced was identified for each infant, and their preferences for the familiar and novel stimuli in trials preceding that point were examined. Infants who saw objects or faces as stimuli both exhibited selective attention to the familiar stimulus prior to preferring novel stimuli, although infants shown kaleidoscope patterns did not. These results document a preference for familiarity early in processing with a procedure that is not subject to ambiguities due to individual differences in processing speed or to collapsing data across infants. The results support a nonlinear model for memory formation during infancy and under-

score recently voiced concerns that in research on cognitive development, infants' attention to perceptual familiarity–novelty must be carefully disentangled from conceptual knowledge.

Fantz's (1964) observation that human infants repeatedly exposed to a visual stimulus subsequently prefer or selectively attend to a novel stimulus catalyzed the field of infant perception. Researchers first seized on the preference for novelty as a means to study infants' basic sensory abilities to discriminate colors, forms, orientations, levels of complexity, and so forth (cf. Bornstein, Kessen, & Weiskopf, 1976; Caron & Caron, 1968, 1969; Cohen, Gelber, & Lazar, 1971; Cornell, 1975; Martin, 1975; McGurk, 1972). The habituation paradigm was next adapted to study higher level perceptual processes, including size and shape constancy (Caron, Caron, & Carlson, 1979; Day & McKenzie, 1981; McKenzie, Tootell, & Day, 1980), memory across delays and interference (Cohen, DeLoache, & Pearl, 1977; Fagan, 1973; Pancratz & Cohen, 1970), and face perception (Barrera & Maurer, 1981; Cohen & Strauss, 1979; Dirks & Gibson, 1977; Fagan, 1972). Currently, methods capitalizing on the novelty preference are also being used to examine cognitive capacities such as categorization (Eimas & Quinn, 1994; Younger, 1993; Younger & Cohen, 1986), individuation and numerosity (Wynn, 1995; Xu & Carey, 1996), and infants' knowledge of the physical world (Baillargeon, 1987; Leslie & Keeble, 1987; Needham & Baillargeon, 1993).

The preference for a novel stimulus is generally taken, both theoretically and empirically, as an indication that a representation of the alternative (familiar) stimulus exists in memory. Models specify that on being confronted with a stimulus, the organism seeks to "match" it with a known quantity from previous experience (see Bornstein, 1985; Cohen & Gelber, 1975; Miller, Galanter, & Pribram, 1960; Sokolov, 1958/1963). If no match pertains, the organism attends to the stimulus and begins to construct a neuronal representation of it; however, to the extent that the stimulus is congruent with something already represented in memory, attention to it is inhibited and deployed elsewhere. With young individuals and complex stimuli, this process is assumed to be incremental, so that both the formation of a representation in memory and the loss of interest in the concordant stimulus unfold over time. The reality of these presumed mental activities is supported by reliable individual differences in the rate of habituation (Bornstein & Benasich, 1986; Colombo, Mitchell, & Horowitz, 1988; Pecheux & Lécuyer, 1983) and significant correlations between the strength of one's preference for novelty in infancy and traditional measures of IQ at later ages (see meta-analytic reviews by Bornstein & Sigman, 1986, and McCall & Carriger, 1993). Thus, habituation to a repeated stimulus and the related preference for novelty are thought to reflect some variable aspect of neurological functioning, such as "speed of processing" or the effectiveness of attentional control and disengagement mechanisms (Bornstein, 1985; Co-

lombo, 1995; Colombo & Mitchell, 1988; Johnson, Posner, & Rothbart, 1991; McCall, 1994).

These interpretations of habituation and the preference for novelty are complicated, though, by observations that infants sometimes prefer the familiar stimulus after exposure rather than a novel one. Initially, it seemed that a preference for the familiar may be an immature response, characteristic only of very young infants (Hunt, 1970; Wetherford & Cohen, 1973). However, in later research, familiarity preferences were also exhibited by older infants, specifically when their exposure to the familiar stimulus was relatively brief (Hunter, Ross, & Ames, 1982; Rose, Gottfried, Melloy-Carminar, & Bridger, 1982; Wagner & Sakovits, 1986) or when the familiar test choice was similar but not completely identical to the stimulus previously experienced (Gibson & Walker, 1984). It is now thought that a preference for the familiar tends to occur when its match with a memory representation is vague or only partial, as would be the case when construction of the representation had only just begun (Hunter & Ames, 1988; Rose et al., 1982; Wagner & Sakovits, 1986). This conceptualization is compatible with earlier, "optimal level" theories of the determinants of infant attention (cf. Berlyne, 1970; McCall, 1971).

This idea, then, is that a preference for the familiar reflects an early phase of processing, whereas a preference for novelty ensues as processing nears completion. This supposed sequence of preferences, however, has not yet been demonstrated over the course of individual instances of forming a representation of a particular, single stimulus. Rather, it has been inferred from the responses of distinct groups of infants exposed to a stimulus for different durations or from the responses of individual infants exposed to several different stimuli, each for a different duration. Furthermore, both of these strategies rely on analyzing the grouped data of all infants exposed to a certain stimulus for a given duration, despite the fact that individual infants may process the stimulus at different rates. Thus, the chance responding observed by Rose et al. (1982) and Wagner and Sakovits (1986) at durations intermediate to those yielding familiarity and novelty preferences could reflect a genuine phase in the formation of a memory representation or it could simply derive from the collapsing together of fast processors already preferring the novel stimulus with slow processors still preferring the familiar.

In the research reported here, we adapted Fantz's (1964) original procedure to assess each infant's preference for familiarity versus novelty multiple times throughout a single, continuing instance of habituation. Our aim was to examine the time course of stimulus processing more precisely and individually than has been done to date. We considered this worthwhile not only to better understand infants' visual processing in and of itself, but also because the issue of a preference for familiarity has become involved in a major debate within the field of infancy. Several researchers (Bogartz, Shinsky, & Speaker, 1997; Bogartz, Shinsky, & Schilling, this issue; Haith, 1998; Schilling, this issue) have questioned the conclu-

sions of Baillargeon and her colleagues (Baillargeon, 1987; Baillargeon & Graber, 1987; Baillargeon, Spelke, & Wasserman, 1985) that very young infants comprehend the permanence and identity of objects. These challengers argued that infants' heightened attention to certain impossible test events may reflect nothing more than a preference for the more familiar test display. In light of this controversy, it is important to further explore the reality of a familiarity preference during infants' processing of visual stimuli.

METHOD

Participants

The final sample consisted of 72 infants (36 boys and 36 girls), each tested within 10 days of being exactly 4½ months old ($M = 145.4$ days, $SD = 5.2$ days). Twenty-six additional infants were also tested but not included in the final sample because of experimenter error and equipment problems ($n = 12$) or because they were too sleepy or fussy to complete at least 15 trials ($n = 14$). All of the infants were full-term and healthy according to parental reports. They were recruited by mail solicitation based on the birth records of several communities neighboring Tufts University. Respondents to the mail solicitation in this area were predominantly White, middle-class, two-parent families. The infants were tested individually in a university laboratory in the presence of a parent, who had provided informed written consent.

Stimuli and Apparatus

Three different sets of stimuli were employed to explore the generality of the effects under investigation. The *objects* set included 35 mm color slides of 25 different commonplace objects (e.g., a coffee mug, a box of crayons, a toy truck, a change purse), each photographed against a black background. The *faces* set included 35 mm color slides of 25 different 4-month-old infants, each facing forward and displaying a neutral expression. These infants were photographed wearing a large black bib and sitting in front of a black drape, so that only the infant's face appeared against a field of black. The *kaleidoscopes* set included 35 mm color slides of 25 different multicolored kaleidoscope configurations, each photographed against a black background. These stimuli were provided by our colleague R. G. Cook, who had employed them in a prior study of animal memory (see Wright et al., 1990). Within each set of 25 stimuli, 6 were randomly selected to serve as a familiar stimulus and multiple duplicates were made of these.

The testing environment consisted of a table with a gray three-sided enclosure. The side panels of the enclosure extended the width of the table and served to pre-

vent the infant from viewing the observers, the recording equipment, and so on. The center panel of the enclosure was a 69 cm tall \times 94 cm wide Polacoat screen, on which the stimulus slides were rear-projected two at a time. When projected, the two stimuli appeared side by side approximately 60 cm in front of the infant and separated by a space of 20 cm (18° of visual angle) and each stimulus covered approximately 50 cm² of the viewing screen.

Procedure and Design

Each infant sat on a parent's lap across the table from the projection screen. The parent was instructed to hold the infant steady and to refrain from soliciting or directing the infant's attention in any way. Each infant was then presented with an initial familiarization (F) trial, followed by a series of at least 14 paired comparison (P) trials. The F trial was intended to establish a minimal level of familiarity with one of the stimuli of the set being shown to the infant (objects, faces, or kaleidoscopes). It consisted of two identical slides of one of the six stimuli selected to serve as familiar. These duplicates were presented side by side for 3 sec starting when the infant had first fixated one or the other of them for 0.1 sec. The subsequent P trials each consisted of a repetition of this same familiar stimulus presented side by side with a different one of the other 24 slides in the relevant set. The order in which the 24 distinct novel stimuli occurred across the various P trials was randomly determined for each infant. Each P trial was presented for 8 sec, starting when the infant had first fixated either one of the stimuli for 0.1 sec. Brief, fixed-length trials were employed so that infants' relative preferences for a familiar versus a novel stimulus could be sampled frequently and at equally spaced, periodic points during the course of processing. Interstimulus intervals were approximately 2 sec to 3 sec, and P trial presentations ensued until the infant became too fussy or disinterested to continue. If an infant was still actively participating after all 24 distinct P trials had been shown, the series of P trials was presented again in the same order.

Twenty-four infants (12 boys and 12 girls) were shown trials with the objects slides, another 24 infants were shown trials with the faces slides, and the remaining 24 were shown trials with the kaleidoscopes slides. Each of the six stimuli chosen from each set of slides to serve as a familiar stimulus was the designated familiar stimulus for 2 boys and 2 girls, with the other five potential targets then serving among the novel stimuli in P trials for those infants. For one half of the infants shown each type of stimulus (objects, faces, kaleidoscopes), the familiar stimulus was always presented on the right side of the screen during P trials; for the other one half of the infants, the familiar stimulus was always presented on the left side. The familiar stimulus was presented on the same side throughout the P trials for any given infant so that infants could actively anticipate where the familiar and novel stimuli would appear (see Haith, Hazen, & Goodman, 1988; Wentworth &

Haith, 1992) and thus deliberately choose to direct their attention toward one or the other during each relatively brief P trial.

Throughout each infant's series of trials, an experimenter crouched behind the projection screen and monitored the infant's visual behavior by looking through a peephole at the bottom center of the screen. This experimenter was naive with regard to the position of the familiar and novel stimuli for each session; she recorded the duration and sequence of fixations to the left and right stimuli on each trial by operating push-buttons connected to a computer. Trial-by-trial interobserver reliabilities with this scoring procedure and similar-aged infants have ranged from $r = .96$ to $r = .99$ in related studies in our laboratory (see Bushnell & Roder, 1985; Roder, Bates, Crowell, Schilling, & Bushnell, 1992). A second experimenter also stationed behind the projection screen operated the computer and the slide projectors. The computer signaled the beginning and end of each trial, and the experimenter advanced the slides accordingly.

RESULTS

A preliminary 2 (sex) \times 6 (familiar stimulus) \times 14 (trials) analysis of variance was conducted for each group on the durations of looking to the familiar stimulus across the first 14 P trials, for which every infant had contributed data. These analyses showed no effects for sex or for the stimulus chosen to serve as familiar for any of the three stimulus types. Thus, within each stimulus type, the data were collapsed across sex and familiar stimulus in all further analyses.

Next, the data for each infant were examined to identify when in the series of P trials the infant began to demonstrate a systematic preference for the novel stimulus. A novelty percentage was calculated for each overlapping block of three successive P trials (e.g., for Trials 2, 3, and 4; Trials 3, 4, and 5; Trials 4, 5, and 6; etc.) for each infant; this novelty percentage was the sum of the durations of looking to the three novel stimuli in the block divided by the sum of the durations of looking to both the novel and the familiar stimuli in the block. Novelty percentages were calculated for blocks of trials rather than for individual trials to reduce variability produced by momentary changes in state and by idiosyncratic preferences for particular stimuli. Our aim was to capture the infant's online preference for "generic" novelty relative to the familiar stimulus. The novelty percentages for each infant were then examined to locate a "critical run" of five consecutive overlapping blocks each exceeding 60%, and the trial number that began this run was noted. This point in the series of P trials was taken to be the point at which the infant had formed a nearly complete representation of the familiar stimulus and was habituated to it. This criterion was intended to be a stringent one, unlikely to be achieved by chance. If the probability of any one block exceeding 60% by chance is crudely and conservatively estimated to be no greater than .5, then the probability that each

of the next four trials (for a total of five consecutive blocks) would also exceed 60% by chance is less than .05, roughly, $(.5)^5 = .031$.

Of the 24 infants in each group, 20 infants shown the objects stimuli, 17 shown the faces stimuli, and 17 shown the kaleidoscopes stimuli evidenced a criterial run. On average, infants who evidenced a criterial run began it at trial 8.0 ($SD = 5.2$) with the objects stimuli, at trial 11.2 ($SD = 7.7$) with the faces stimuli, and at trial 10.2 ($SD = 5.5$) with the kaleidoscopes stimuli. There were 7 infants shown the objects stimuli, 2 shown the faces stimuli, and 2 shown the kaleidoscopes stimuli who began the criterial run at the very first P trial. These data suggest that the objects stimuli were processed somewhat more quickly than the faces and kaleidoscopes stimuli.

The behavior of the few infants in each group who never achieved a criterial run toward the novel stimulus is ambiguous. It is possible that these infants were relatively slow processors and never formed a sufficiently complete representation of the familiar stimulus to be habituated to it. However, it is also possible that these infants merely had a spontaneous attraction to the particular familiar stimulus they were shown or a bias toward the side on which it was shown. Similarly, the infants who began the criterial run at the first P trial may have been very fast processors who formed an essentially complete representation of the familiar stimulus from just the brief F trial exposure to it. Alternatively, they may have had a spontaneous aversion to the familiar stimulus they were shown or a side bias toward the side where the novel stimulus was shown.

In the subsequent analyses on the time course of forming a representation, both those infants who never achieved a criterial run and those who achieved it beginning at the first P trial were eliminated. One way to look at these exclusions is that we examined data only from the infants in the most normative (for their age) portions of the processing speed continuum; very fast and very slow processors were considered "outliers" whose data could have unduly influenced the results of primary interest. Another way to look at the exclusions is that we examined data only from infants who attended to both stimuli and to both sides during the early P trials.

For each infant retained as outlined previously, we next examined the relative preference for the familiar as compared with the novel stimulus from the first P trial to the trial that began the criterial run; that is, over the trials during which the infant was presumably forming a sufficient (for habituation) representation of the familiar stimulus. Note that the number of precriterial trials involved here was different for each infant; it depended on when the criterial run was achieved. Thus, this analysis was something like Cohen and Gelber's (1975) use of "backward habituation curves," except that we did not then collapse the data for each precriterial trial across infants. Instead, the total duration that each infant looked toward the familiar stimulus over the course of the precriterial trials was divided into deciles to approximate the points at which the individual infant's processing of the familiar stimulus was 10% completed, 20% completed, 30% completed, and so forth. Next,

the duration of looking toward the novel stimulus during each of the 10 intervals defined by fractions of attention to the familiar stimulus was noted, and a novelty percentage for each decile was computed. This treatment of the data effectively standardized it across infants, so that relative preferences for the familiar versus the novel stimuli could be evaluated at proportionally equivalent points during processing despite individual differences in processing speed. Thus, the values in successive deciles reflect the unfolding of an infant's preference for a stimulus as it became increasingly recognizable.

The mean novelty percentages for each decile and each stimulus type are displayed in Table 1. Also displayed in Table 1 are two-tailed *t* values comparing each decile mean with the 50% to be expected by chance. Note that except for two deciles with the kaleidoscopes stimuli, all of the novelty percentages in Table 1 are less than 50%, indicating a consistent preference for the familiar stimulus during precriterial processing. This preference is especially clear with the objects and faces stimuli, where the novelty percentages for more than half of the deciles are significantly less than 50% in each case.¹

However, it should be noted that the novelty percentages for the later deciles shown in Table 1 may favor the familiar stimulus partly because of how criterial runs were defined. That is, for each infant, the novelty percentage for the trial block immediately preceding the criterial run had to be 60% or less; if it were greater than 60%, that block would have begun the criterial run (see also Cohen & Menten, 1981). This constraint would involve a different number of deciles for each infant, depending on how many P trials preceded the criterial run. For example, a few infants achieved the criterial run after just four or five trials; for these infants each decile represents only a fraction of a trial in time, and therefore, the values in as many as the last three deciles (70% to 100%) could be artifactually low. At the other extreme, a few infants took 20 or more trials to reach criterion; for these infants a decile might represent several trials in time, and thus only the latter portion of the very last decile might be affected. For most infants, all of the values are valid except for perhaps the one in the last decile.

We also examined the different portions of each infant's processing time in another way. These additional analyses do not provide as complete a picture as the deciles analyses, but they are not subject to the previously discussed constraint. For the second set of time-course analyses, we again worked backward from the

¹Although the data in Tables 1 and 2 derive from a subset of the full sample of infants tested, that subset includes infants who were tested with each of the six possible familiar stimuli within each stimulus type. Hence, the familiarity preferences observed were not due to any incidental differences in stimulus salience. Similarly, the infants represented in Tables 1 and 2 include some who saw the familiar stimulus on the right and some who saw it on the left. With the objects stimuli, 7 infants saw the familiar stimulus on the right and 6 saw it on the left; with the faces stimuli, 7 infants saw the familiar stimulus on the right and 8 on the left; and with the kaleidoscopes stimuli, 9 infants saw the familiar stimulus on the right and 6 on the left.

TABLE 1
Mean Novelty Percentages for Each Stimulus Type for Standardized Deciles of Precriterial Processing

<i>Stimulus Type</i>	<i>Decile of Precriterial Processing</i>									
	<i>0%–10%</i>	<i>10%–20%</i>	<i>20%–30%</i>	<i>30%–40%</i>	<i>40%–50%</i>	<i>50%–60%</i>	<i>60%–70%</i>	<i>70%–80%</i>	<i>80%–90%</i>	<i>90%–100%</i>
Objects										
<i>M</i>	33.85	39.92	37.46	29.85	29.38	34.30	32.30	26.31	38.85	43.54
<i>SD</i>	24.30	26.62	23.44	21.98	25.27	20.70	24.84	23.21	19.57	20.65
<i>t</i> (12)	2.30*			3.17***	2.82**	2.63**	2.47*	3.53***	2.50*	
Faces										
<i>M</i>	45.31	30.25	37.50	31.56	21.38	36.00	37.63	25.19	22.06	23.13
<i>SD</i>	29.00	27.44	27.35	27.03	23.37	27.59	27.59	27.88	28.99	26.86
<i>t</i> (15)		2.79**		2.64**	4.74***			3.45***	3.73***	3.87***
Kaleidoscopes										
<i>M</i>	38.33	47.80	53.67	51.47	46.60	44.93	46.20	29.60	32.87	32.53
<i>SD</i>	28.43	29.22	22.39	21.31	30.53	30.81	22.07	30.77	27.93	28.81
<i>t</i> (14)								2.48*	2.29*	2.26*

Note. Infants who did not achieve a criterial run or who achieved it beginning at the first preference trial are excluded from this analysis. *t* values are for one-sample tests of each novelty percentage against the chance value of 50%. Probabilities are two tailed.

p* < .05. *p* < .02. ****p* < .01.

trial that began the criterial run for each infant. Unlike the trial just before the criterial run, the trial that was two before the run (e.g., Trial 10 if the run began at Trial 12) was not constrained by its definition; we therefore took the three-trial block ending with this last “pure” trial to represent a “late” portion of each infant’s processing of the familiar stimulus. We then took the block of three trials midway between the first P trial and the trial that began the infant’s criterial run to represent a “middle” portion of processing and the first three P trials to represent an “early” portion of processing. Note that for infants who achieved the criterial run relatively soon in the series of P trials, the trials involved in the early, middle, and late portions of processing might overlap, whereas for infants who achieved the run later in the series, the trials involved would be separated by a number of other P trials. Thus, as with the deciles procedure, this treatment of the data identified proportionally equivalent points during processing despite individual differences in processing speed. The units of time sampled were always three-trial blocks, though, rather than individually tailored fractions of each infant’s processing time as in the deciles analyses.

The mean looking times and novelty percentages for the early, middle, and late portions of precriterial processing for each stimulus type are displayed in Table 2. We have also included the same measures for the very last (hence, postcriterial) block of trials for comparison. Within each stimulus type, the novelty percentages for each portion of processing were compared to the chance value of 50% with two-tailed *t* tests. As with the decile analyses, the results of these analyses indicate a clear preference for the familiar stimulus during precriterial processing with the objects and the faces stimuli. This preference is evident during all three portions of precriterial processing with the objects stimuli and during the middle and late portions with the faces stimuli. With the kaleidoscopes stimuli, however, there is again no evidence for an early preference for the familiar stimulus; instead, infants shown these stimuli favored the novel stimulus during the early and middle trial blocks prior to the criterial run.

The pattern of results indicated in Table 2 is also evident when the behavior of individual infants is considered. Of the 13 infants included in the analyses for the objects stimuli, 9, 8, and 9 of them looked longer at the familiar than at the novel stimulus during early, middle, and late processing, respectively, and of the 15 infants included for the faces stimuli, 9, 12, and 11 of them did so. For the kaleidoscope stimuli, though, just 3, 3, and 4 of the 15 infants looked longer at the familiar stimulus during the successive phases of precriterial processing. With all three types of stimuli, infants generally continued to favor the novel stimulus once they had achieved the criterial run. For instance, on the last block of trials shown to them (well beyond the criterial run—see Table 2), 11 of the 13 infants included in the objects analyses, 11 of the 15 included in the faces analyses, and 12 of the 15 included in the kaleidoscopes analyses looked longer at the novel than at the familiar stimulus. This continued preference for the novel stimulus after the criterial run

TABLE 2
Mean Looking Times and Novelty Percentages for Unconstrained Portions of Pre- and Postcritical Processing

	Precritical Processing									Postcritical Processing				
	Early Processing			Middle Processing			Late Processing			Final Block of Trials				
	Sec to Familiar	Sec to Novel	Novelty %	Sec to Familiar	Sec to Novel	Novelty %	Sec to Familiar	Sec to Novel	Novelty %	Trials to Criterion	Sec to Familiar	Sec to Novel	Novelty %	Last Trial
Objects														
<i>M</i>	11.8	7.8	40.8	11.7	7.7	39.7	11.4	7.2	37.5	11.1	5.0	12.7	72.0	29.7
<i>SD</i>	4.2	3.6	16.2	3.7	3.4	15.4	2.7	3.6	14.4	3.6	5.0	6.3	26.3	10.1
<i>t</i> (12)			2.04*			2.42**			3.14***				-3.01**	
Faces														
<i>M</i>	10.2	9.7	46.5	11.7	7.1	35.3	11.3	7.8	40.0	12.5	6.4	10.2	60.5	27.6
<i>SD</i>	4.6	5.9	25.1	4.5	5.2	24.6	4.0	4.2	21.8	7.4	4.5	5.8	26.7	6.3
<i>t</i> (14)			.55			2.32**			1.78				-1.53	
Kaleidoscopes														
<i>M</i>	8.3	11.9	59.0	7.3	11.0	58.7	7.5	10.7	55.3	11.3	5.1	11.3	66.0	23.5
<i>SD</i>	3.2	3.2	12.8	1.6	3.9	12.0	2.2	4.8	18.0	4.9	3.9	6.7	28.4	5.3
<i>t</i> (14)			-2.73**			-2.82**			-1.15				-2.18**	

Note. Infants who did not achieve a criterial run or who achieved it beginning at the first preference trial are excluded from these analyses. Two-tailed *t* tests versus 50%. * $p < .05 < p < .10$. ** $p < .05$. *** $p < .01$.

(where such a preference exists by definition) supports our reasoning from probabilities that the run is a valid index of habituation.

DISCUSSION

The results for two of our three stimulus types indicate that over a series of choice trials, there was a systematic preference for the familiar stimulus prior to a robust preference for novelty. Infants shown everyday objects and those shown infant faces both exhibited a phase of selective attention to a target stimulus that was repeated on every trial before they ultimately shifted to exhibit a consistent preference for a novel stimulus. These results corroborate the notion that the time course of forming a memory representation in infancy involves an initial familiarity preference as the representation is beginning to coalesce, followed by a novelty preference once the representation is nearer completion. This progression had previously been inferred from results with distinct groups of infants whose processing was interrupted after exposures of different durations (Hunter et al., 1982; Rose et al., 1982; Wagner & Sakovits, 1986). Here however, the progression is confirmed over the course of individual, continuing instances of processing. That is, the same infants who preferred a given stimulus after short exposure later favored an alternative to that same stimulus after continued exposure. Thus, the sequence of preferences we observed could not have been affected by any ambiguities due to individual differences or due to collapsing data across infants.

A second interesting finding is that our results give no indication that a period of no preference separates the preferences for familiarity and novelty. Instead, our results show that once the familiarity preference is established for individual infants, it remains fairly robust before giving way, rather abruptly, to the novelty preference. This suggests that the "random preference" sometimes observed following the preference for familiarity in prior research (see Rose et al., 1982; Wagner & Sakovits, 1986) is probably an artifact of grouping data.

The fact that a preference for familiarity precedes the preference for novelty as infants examine visual stimuli means that the formation of memory representations is neither a linear nor an all-or-none process. At the very least, three stages are involved; an initial neutral stage prior to any significant exposure, an intermediate stage corresponding to the familiarity preference, and a final stage corresponding to the novelty preference. Thus, theories and simulations of infant attention and memory will need to incorporate these distinct preferential phases. Certainly from a utilitarian point of view, a preference for familiarity early in processing that is eventually supplanted by a preference for novelty is an adaptive arrangement. The former ensures that sufficient attention is devoted to any given visual input for its representation in memory to be rich in detail and well consoli-

dated, whereas the latter ensures that attention is eventually released for processing other stimuli. This allows information in the environment to be dealt with comprehensively as well as serially, enabling accurate and long-term recognition for a vast array of objects and events.

In contrast to the results with the objects and faces stimuli, the results with the kaleidoscopes stimuli did not reveal a familiarity preference during precriterial processing. If anything, infants shown these patterns may have preferred the novel stimulus during early and middle processing, although not robustly enough to meet our criterion. We have no compelling explanation for this exceptional result, other than to note that the kaleidoscope stimuli differed from the other two types in several ways. Although in some cases they differed drastically in color, they were all highly similar in configuration (i.e., all were symmetrical, hexagonal designs). They were also meaningless stimuli and ones with which infants would probably have had no previous experience. Because of one or more of these features, the kaleidoscope stimuli may have evoked more back-and-forth comparisons (thus, less preferential responding) during processing. Another possibility is that our criterion for identifying the point of habituation may have been less appropriate with these stimuli. At any rate, the kaleidoscope results suggest that an early preference for the familiar may not exist or may not be readily tapped with every kind of visual stimuli. This qualification imposes yet another layer of complexity on models and theories of infant attention.

Still further complexity may stem from the matter of simultaneous versus sequential presentations. For some purposes, researchers have treated these two procedures as interchangeable, although others have held that they may not tap infants' perceptual abilities with equal sensitivity. Theoretically, a simultaneous presentation may offer a simpler task, in that infants have a choice between a familiar and a novel stimulus both of which are physically present. Sequential presentation, on the other hand, may put a greater strain on memorial resources in that the infant's comparison is between a single physically present stimulus and one that is held in memory. Although we would expect the same pattern of preferences in either case, it would not be surprising if the shift to preferring novelty occurred later in the sequence with the more difficult task.

In any case, our results clearly show that with at least some kinds of stimuli, the very same infant may prefer either the familiar stimulus or a novel one, depending on when in the time course of processing the choice is offered. This principal finding would not affect conclusions concerning simple discrimination or memory abilities, in which case either kind of systematic preference is logically diagnostic. However, for conclusions regarding conceptual issues such as infants' understanding of objects or numerosity, our finding has important implications. Consider, for example, studies purporting to show that infants are capable of discriminating between physically possible and impossible events (e.g., objects seemingly disap-

pearing as in Baillargeon, 1987). In these studies, greater visual interest in the impossible event is taken as awareness that physical laws governing the natural world have been violated. However, these studies do not take into account preferential responses in the context of familiarization time. If familiarization is brief, we would expect a preference for whichever test event is more perceptually similar to the habituation experience. Thus, in the Baillargeon study, preference for the impossible event could have occurred not because of a conceptual understanding of object permanence, but because that event more closely resembled the habituation experience. The point is that researchers relying on comparisons of visual interest for disparate events must find ways to ensure that conceptual abilities can be disambiguated from preferential responses that vary systematically as a function of level of familiarity.

This is an attainable goal. For example, following the lead of Bogartz et al. (1997, this issue), infants may be tested after differing periods of exposure to the initial familiarization stimulus. Alternatively, the familiarization stimulus could be made perceptually more similar to the possible test event for some infants and to the impossible one for others (see Schilling, this issue). These methodological cautions become even more critical when one considers the wide range of individual processing speeds highlighted by our procedure. Even after we excluded infants who may have been the very fastest and slowest processors, some of the remaining infants achieved our criterion for full processing after just 4 or 5 preference trials, whereas others of the same age continued to show interest in the familiar stimulus for as many as 25 or more trials before achieving the criterion. Indeed, the method employed here could provide a useful tool for assessing processing speed and readiness to disengage under different conditions. Like infant-controlled criteria for habituation, this method accommodates individual differences, but it does so with repeated online checks against a novel stimulus rather than by keying on attention to the familiar stimulus alone. Thus, nearly 4 decades after Fantz's (1964) original observation, adaptations of his method may continue to hold promise for the field of infancy.

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