

# What form of memory underlies novelty preferences?

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Novelty preferences (longer fixations on new stimuli than on previously presented stimuli) are widely used to assess memory in nonverbal populations, such as human infants and experimental animals, yet important questions remain about the nature of the processes that underlie them. We used a classical conditioning paradigm to test whether novelty preferences reflect (1) a stimulus-driven bias toward novelty in visual selective attention or (2) explicit memory for old stimuli. Results indicated that conditioning affected adults' looking behavior in the visual paired comparison, but not their recognition memory judgments. Furthermore, the typically observed novelty preference occurred only when a bias toward novelty had no competition from a bias toward salience due to conditioning. These results suggest that novelty preferences may reflect attentional processes and implicit memory to a greater degree than explicit memory, a finding with important implications for understanding memory in nonverbal populations and the development of memory in humans.

A widely used method for testing memory in preverbal infants and nonhuman primates, as well as in adults, is the visual paired comparison (VPC). In this paradigm, two visual stimuli are presented simultaneously—one that was presented previously and one that is novel—and the length of time that observers look at each stimulus is measured. Human infants (e.g., Fantz, 1964), adults (e.g., McKee & Squire, 1993), and nonhuman primates (e.g., Nemanic, Alvarado, & Bachevalier, 2004) typically look longer at novel than at old (familiar) stimuli. This *novelty preference* reflects the influence of memory on subsequent visual processing and has great utility as a nonverbal measure of memory, but important questions remain about the nature of the processes that underlie it. In this article, we report a new familiarity-to-novelty shift within VPC trials and describe tests of what form of memory underlies novelty preferences. These results have important implications for understanding the ontogeny of memory in humans.

## **Familiarity-to-Novelty Shifts Within Individual Trials**

The typical dependent measure examined in the VPC is the *novelty score*, which is computed as the proportion of time participants look at the novel stimulus within VPC trials, each of which may last 5 sec or more. The main utility of a large novelty score (>50%) averaged over multiple trials is to infer memory for the old stimuli, but some attention has been paid to changes in looking behavior over time. In particular, research with infants, in which

one item in a pair remains the same across test trials, while the other item changes, has shown that infants tend to look longer at repeated (familiar) stimuli during early test trials, but longer at novel stimuli during later test trials (e.g., Roder, Bushnell, & Sasseville, 2000; Rose, Gottfried, Melloy-Carminar, & Bridger, 1982).

Recent computational modeling of the VPC suggests that this familiarity-to-novelty shift in looking behavior may also take place within individual test trials (Sirois & Mareschal, 2004). Although no previous study has examined infant looking behavior within test trials, data from one study suggest that adults may show a tendency to look first at the familiar stimulus very early in the trial (during roughly the first second), followed by a tendency to look longer at the novel stimulus during the rest of the trial (Manns, Stark, & Squire, 2000). Since the tendency to look first at the familiar picture was not tested statistically or discussed by those authors, we tested this effect in the present study.

In Manns et al. (2000), the tendency to look first at the familiar picture was relatively small in magnitude, possibly because Manns et al. used preexperimentally familiar stimuli (i.e., color photographs of common objects). It is important to note that Sirois and Mareschal's (2004) models predict a larger effect of first looks to old stimuli with fewer previous presentations. We therefore used preexperimentally novel random polygons as stimuli to enhance the likelihood of finding familiarity preferences early within testing trials in adults.

### Potential Causes of Novelty Preferences

In addition to testing possible familiarity-to-novelty shifts within trials, a main purpose of the present study was to test alternative theories about what underlies the (later) novelty preference in VPC trials. One hypothesis stems from an attention-based theory involving biased competition, and the other stems from a memory-based perspective involving explicit memory. We examined these questions in adults in order to avoid inferential problems associated with tests of “explicit” memory in nonverbal populations. Critically, current theories about the type of memory that supports novelty preferences in infants have been derived primarily from work with adults and fully mature experimental animals.

**The biased competition hypothesis.** According to the *biased competition model* of visual selective attention (Desimone & Duncan, 1995), the visual system has a limited capacity for processing information, so objects must compete for processing resources. This competition is biased by bottom-up and top-down factors. Bottom-up biases are defined as automatic and unrelated to intentions or goals and include stimulus-driven biases (e.g., toward certain colors, high-contrast stimuli, movement, etc.), as well as biases from information stored in long-term memory that may influence early perceptual processing. A classic example of the latter type of bias is the automatic orienting to the sound of one’s name spoken in a noisy room (i.e., the “cocktail party effect”). Desimone and Duncan propose that this type of bias arises from the “learned importance” (p. 201) of a stimulus. Another important bias that is stimulus driven, but also reflects previous processing, is the bias toward novelty (see, e.g., Reicher, Snyder, & Richards, 1976). In VPC trials, novelty preferences may reflect the tendency for attention to be automatically allocated to the more novel of two stimuli. Desimone and Duncan relate this bias with repetition priming effects that can occur independently of explicit memory for old stimuli.

Critical predictions can be derived from this theory. Novelty preferences may occur when the bias toward novelty has no competition. However, if a form of learned salience occurs during initial exposure to repeated stimuli, the bias toward salient stimuli may compete with the bias toward novelty, diminishing, or perhaps even reversing, novelty preferences in the VPC. We tested this prediction by manipulating the learned salience of familiar stimuli (via classical conditioning) and then examining the effects of learned salience on looking during test trials. If the typically observed novelty preference in the later parts of trials reflects one of multiple competing biases in visual selective attention, then novelty preferences may be observed only when familiar stimuli have no particular salience.

**The explicit memory hypothesis.** A more widely accepted view of novelty preferences is that they reflect a form of explicit or declarative memory (e.g., Nelson, 1995). This is a viable hypothesis in part because amnesic patients with impaired explicit memory have been shown to be impaired in exhibiting novelty preferences (McKee & Squire, 1993), although there are alternative interpretations of these results (Snyder, 2007). Thus, explicit

memory for the familiar stimulus may be responsible for novelty preferences.

With regard to effects of learned salience, the explicit memory hypothesis makes different predictions than does the biased competition hypothesis. One possibility is that explicit memory supports the learning of salience. If so, learned salience should have similar effects on looking behavior and explicit memory expression (tested independently of looking behavior). Another hypothesis, however, is that another form of memory supports the learning of salience independently of explicit memory. This is plausible because affective classical conditioning can occur independently of explicit memory for the contingencies during learning (Baeyens, Eelen, & Van den Bergh, 1990). According to this hypothesis, learned salience may have no effect on novelty preferences in the VPC, because learned salience would be supported by a form of memory other than explicit memory, and explicit memory supports novelty preferences. Thus, we conducted an explicit memory control experiment to test these possibilities.

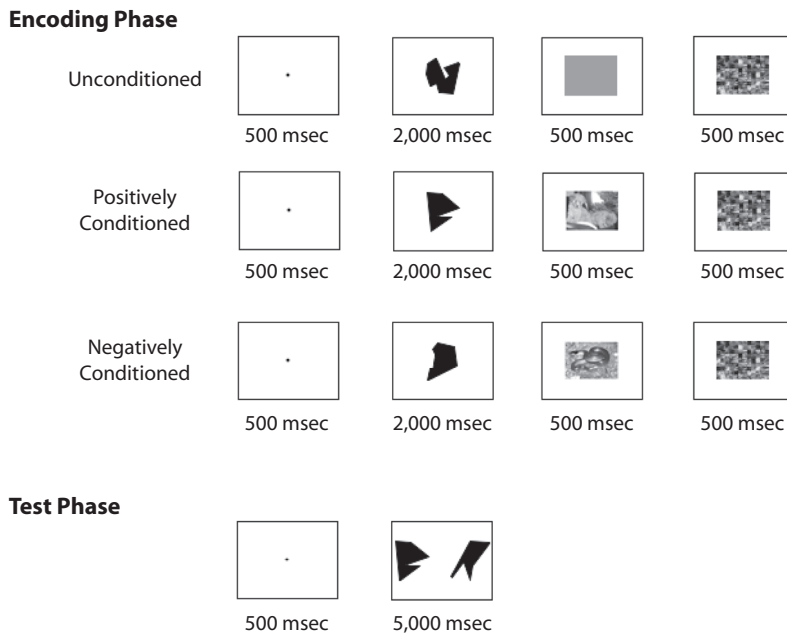
**The present study.** Participants encoded preexperimentally novel polygons that were paired with positive or negative slides from the International Affective Picture System (IAPS; Center for the Study of Emotion and Attention, 1999) or with a neutral gray panel (see Figure 1). After a short delay, participants viewed pairs of previously seen and novel polygons. Half of the participants (assigned at random) viewed the polygons under free-viewing conditions while we recorded looking behavior (VPC), and the other half were asked to indicate which polygon they had seen before (explicit recognition task). We first tested whether initial looks within individual VPC trials were toward the old (familiar) stimulus, as predicted by recent computational models (Sirois & Mareschal, 2004). We then tested whether novelty preferences later in the trials were due to biased competition in visual selective attention or to explicit memory for the familiar stimulus, by examining the effect of conditioning during encoding (unconditioned, positively conditioned, or negatively conditioned) on looking behavior and recognition memory performance.

The biased competition hypothesis posits that conditioning will influence novelty preferences, so novelty preferences will be observed only in unconditioned trials and not in positively or negatively conditioned trials (when the bias toward salience and the bias toward novelty compete). Alternatively, the explicit memory hypothesis predicts that conditioning (1) will have the same effect on looking behavior and recognition memory (if the learning of salience is explicit memory based) or (2) will not influence novelty preferences (if the learning of salience is not explicit memory based).

## METHOD

### Participants

Ninety-six undergraduate students at the University of Minnesota volunteered. Half of the participants (24 female) were randomly assigned to the VPC task, and the other half (24 female) were assigned to the recognition memory task. All of the participants received course credit or cash payment for participating.



**Figure 1. Schematic representation of the paradigm.** In each encoding trial, a fixation point was presented for 500 msec, followed by a polygon for 2,000 msec, a neutral gray rectangle or an IAPS picture for 500 msec, and a mask (to control presentation time for the IAPS picture) for 500 msec. The polygons were unconditioned in 16 trials, positively conditioned in 16 trials, and negatively conditioned in 16 trials. The test phase followed shortly after the encoding phase. In each test trial, a fixation point was presented for 500 msec, followed by two polygons, one old and one new, presented simultaneously for 5,000 msec. In the visual paired-comparison task, participants were instructed to look at the polygons for the entire time that they were presented, and eye movements were recorded. In the recognition memory task, participants were instructed to indicate which of the polygons was old by pressing a marked key on the keyboard.

## Materials

Ninety-six random polygons were selected from Vanderplas and Garvin (1959a). Six lists of 16 polygons were generated and counterbalanced on complexity (number of points per polygon; 6, 8, 12, and 16), association (likelihood that the shape reminds people of some object or situation), content (likelihood that the shape reminds people of something reportable in a word or phrase), and heterogeneity (amount of information per response in the content measure).<sup>1</sup> Polygons were solid black against a white background and fit within a 12 × 12 cm space. Five additional polygons were used as filler items during the encoding phase (three at the beginning and two at the end) to attenuate primacy and recency effects, and four pairs of additional polygons were used for warm-up trials during the test phase of the VPC task.

Thirty-two photographic slides from the IAPS were used as emotion-provoking stimuli paired with polygons during the encoding phase. Sixteen of the slides were highly positive (mean valence rating = 7.16) and highly arousing (mean arousal rating = 6.07), and the other 16 were highly negative (mean valence rating = 2.86) and highly arousing (mean arousal rating = 6.08), according to affective rating norms from equal numbers of female and male raters (Lang, Bradley, & Cuthbert, 1999).<sup>2</sup> Each slide was sized to fit a 16 × 12 cm space. In addition, a gray 16 × 12 cm rectangle was used as a neutral stimulus during the encoding phase, and a highly scrambled neutral photographic slide was used as a backward pattern mask during the encoding phase.

Stimulus presentation was controlled by a Macintosh computer running PsyScope software (Cohen, MacWhinney, Flatt, & Provost, 1993). A high-resolution VHS videocassette recorder, camera, and time/date generator were used to videotape participants' look durations during the VPC task at 30 frames per sec.

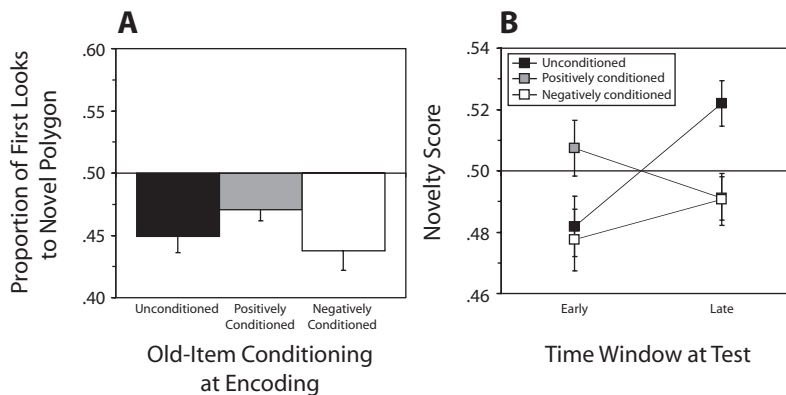
## Procedure

The initial encoding phase was the same for both groups of participants, and it was followed by either the VPC task (for one group) or the recognition memory task (for the other group; see Figure 1).

**Encoding phase.** The encoding phase consisted of 48 trials (plus 5 filler trials to attenuate primacy and recency effects). Participants were told that the purpose of this task was to investigate eye movements that people naturally make when viewing unfamiliar shapes. Each trial began with a short beep, followed by a central fixation point for 500 msec. A polygon then appeared in the center of the display for 2 sec. Participants were told to look at and pay attention to the polygon for the entire time it was displayed. Immediately after the offset of the polygon, an affective slide or the gray rectangle appeared centrally for 500 msec, and then the mask appeared centrally for 500 msec. The mask was used solely to attenuate iconic memory for the preceding slide; it was not used to present stimuli in a subliminal manner. The next trial began 1 sec after the previous trial, and the display was blank during this intertrial interval.

For each participant, the gray rectangle appeared after each of the polygons in 16 trials, one of the positive IAPS slides appeared after each of the polygons in 16 trials, and one of the negative IAPS slides appeared after each of the polygons in 16 trials. Trial orders were pseudorandomized so that no more than three consecutive trials represented the same type of conditioning (unconditioned, positively conditioned, or negatively conditioned), level of complexity of the polygon (6, 8, 12, or 16 points), or side of presentation of the polygon in the subsequent test phase (left or right).

**Test phase.** For half of the participants, the test phase consisted of 48 VPC trials (plus 4 warm-up trials) in which a previously seen (i.e., old) polygon and a new polygon were presented simultane-



**Figure 2. (A) Proportion of first looks to the novel polygon (chance = .5) within individual trials in the VPC is displayed as a function of type of conditioning of the old polygons during encoding. (B) Mean novelty scores (chance = .5) in the VPC task are displayed as a function of time window within individual trials and type of conditioning of the old polygons during encoding. Error bars indicate standard errors of the means.**

ously while eye movements were recorded. Each trial began with a short beep, followed by a central fixation point for 500 msec. Two polygons then appeared simultaneously for 5 sec (the distance between polygons was  $35.4^\circ$  for half of these participants and  $18.2^\circ$  for the other half; results indicated no significant differences in performance between these groups). Participants were told to look at and pay attention to the pair of polygons during the entire time they were displayed. In each trial, both polygons were of the same complexity. Across participants, polygons were rotated through the old versus new conditions, the three types of conditioning during encoding, and the left–right position of the screen at test, so that each polygon represented each of those conditions an equal number of times across participants. Trial orders were pseudorandomized so that no more than 3 consecutive trials represented the same type of conditioning (unconditioned, positively conditioned, or negatively conditioned), level of complexity of the polygons (6, 8, 12, or 16 points), or side of presentation of the old polygon (left or right).

For the other half of the participants, the test phase consisted of 48 explicit memory trials in which an old polygon and a new polygon were presented simultaneously while participants performed a forced-choice recognition memory test. The materials and procedure were the same as those used for the VPC trials, except the instructions were different. Participants were instructed to look at the pair of shapes during the entire time that the pair was displayed, and then to indicate, after the disappearance of the pair, which polygon was old and which polygon was new by pressing one of two marked keys on the computer keyboard. This response was followed by a three-point judgment of confidence in the preceding response.

#### Looking-Time Data Scoring

Following Manns et al. (2000), participants' visual fixations during the VPC task were coded offline from videotape by two independent raters who were blind to the left–right location of the old polygon across trials. Mean rater agreement was .96. One participant was dropped from the analysis because of erratic looking behavior that did not enable reliable scoring. Novelty scores were computed as the proportion of time participants spent fixating on the new polygon over the time they spent fixating on either the old or new polygon (not including looks to the center or eyeblinks) during each 5-sec test trial.

## RESULTS

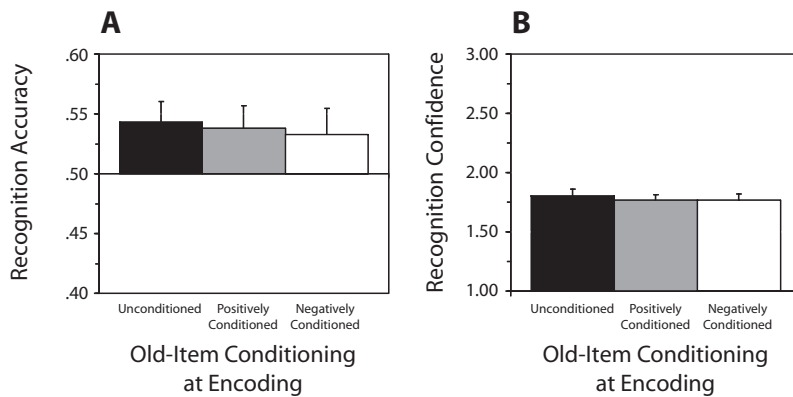
### The VPC Task

We first tested whether first fixations within individual trials tended to be toward familiar stimuli. The proportion

of first fixations to the novel polygon was significantly smaller than chance (.5) in all conditions, indicating greater looking to old stimuli (see Figure 2A) on unconditioned trials (.449) [ $t(46) = -3.376, p < .01, d = .55$ ], on positively conditioned trials (.471) [ $t(46) = -2.18, p < .05, d = .32$ ], and on negatively conditioned trials (.438) [ $t(46) = -4.02, p < .01, d = .59$ ]. The magnitudes of these effects did not differ across conditions, as confirmed by a nonsignificant main effect of type of conditioning in a repeated measures ANOVA [ $F(2,92) = 1.59, MS_e = .0084, p > .20$ ].

We then analyzed data from all fixations within trials. Mean novelty scores were submitted to a repeated measures ANOVA, with old-item conditioning during encoding (unconditioned, positively conditioned, or negatively conditioned) and time window during test (early/0–1,500 msec or late/1,500–5,000 msec) as within-participants independent variables. The interaction between type of conditioning and time window was significant (see Figure 2B) [ $F(2,92) = 3.97, MS_e = .019, p < .05, \eta^2 = .035$ ]. For unconditioned trials, a marginally significant familiarity preference was found in the early time window (.482) [ $t(46) = -1.99, p < .06, d = .29$ ], but this changed to the typically observed, significant novelty preference in the late time window (.522) [ $t(46) = 3.09, p < .01, d = .46$ ]. In contrast, no novelty preference was found in the late time window for the positively conditioned trials (.491) or for the negatively conditioned trials (.491) (both  $ps > .2$ ). Other effects were a significant main effect of conditioning [ $F(2,92) = 3.68, MS_e = .0024, p < .05, \eta^2 = .016$ ] and a main effect of time window that approached significance [ $F(1,46) = 3.12, MS_e = .0034, p < .09, \eta^2 = .015$ ].

The finding that the novelty preference observed in the unconditioned trials was diminished when the old stimuli were learned to be salient (were positively or negatively conditioned) supports the biased competition explanation for novelty looking effects. Another way to test this hypothesis is to take advantage of intrinsic differences in the initial “likability” of the novel polygons. We reasoned that



**Figure 3. (A) Mean forced-choice recognition accuracy (chance = .5) in the explicit memory task is displayed as a function of type of conditioning of the old polygons during encoding. (B) Mean confidence in recognition judgments (on a 1–3 scale) for correct-recognition trials is displayed as a function of type of conditioning of the old polygons during encoding. Error bars indicate standard errors of the means.**

relatively liked polygons overlap with preexisting shape representations to a greater degree than do relatively disliked polygons (see, e.g., mere exposure effects on subsequent liking judgments of previously novel stimuli; Kunst-Wilson & Zajonc, 1980). If so, greater likability of the novel polygons in our test pairs should be correlated with weaker attentional biases toward novelty (reflected in novelty scores). Thus, we asked an additional group of 24 participants to choose which polygons of the test pairs used in the experiment were intrinsically more likable (when none of them had been viewed previously). In line with our hypothesis, we observed a significant negative correlation between the likability of the novel polygon of each test pair and the novelty score for that test pair in the unconditioned, late time-window condition of the experiment ( $r = -.22, p < .05$ ).

### Recognition Memory

Overall, recognition memory accuracy, measured as the proportion of trials in which the old polygon was correctly selected as “old,” was significantly greater (.538) than chance (.500) [ $t(47) = 2.67, p < .05, d = .39$ ]. To examine whether old-item conditioning during encoding affected performance, recognition accuracy was submitted to a repeated measures ANOVA with type of conditioning (unconditioned, positively conditioned, or negatively conditioned) as the within-participants independent variable. In contrast to looking behavior, recognition memory did not differ depending on old-item conditioning ( $F < 1$ ; see Figure 3). Similarly, level of confidence in correct recognition judgments ( $F < 1$ ) and in all recognition judgments ( $F < 1$ ) did not differ depending on old-item conditioning in additional ANOVAs. Also in contrast to looking behavior, the likability of the novel polygon of each test pair was unrelated to recognition memory performance ( $r = -.08, p > .45$ ).

The findings that old-item conditioning affected looking behavior in the VPC (but not recognition memory) and that likability of the novel polygons was associated with looking (but not recognition) provides evidence that

the VPC and the recognition task tap different memory systems. A double dissociation between VPC performance and recognition memory would provide additional evidence against the hypothesis that these two forms of memory are supported by the same memory system. We therefore tested whether another variable would affect recognition memory but not looking behavior. Vanderplas and Garvin (1959b) examined forced-choice recognition memory for many of the same random polygons that we used, and they reported that complexity of the old polygon affected recognition memory: Recognition accuracy decreased in a linear fashion with increasing complexity of the old polygon (for a more recent replication of this pattern of results with other novel shapes, see Liu, Kersten, & Knill, 1999). We therefore tested the a priori prediction that complexity of the old polygon should have a linear effect on recognition memory performance. We calculated a final repeated measures ANOVA on the recognition memory data and novelty scores using complexity of the old polygon (6, 8, 12, 16 points) as a within-participants independent variable, and type of test (recognition memory or novelty scores) as a between-participants variable. A linear contrast revealed that recognition memory was affected by complexity of the old polygon, with recognition accuracy decreasing from least to most complex polygons (.58, .53, .50, and .54 for polygons with 6, 8, 12, and 16 points, respectively) [ $F(1,279) = 4.00, MS_e = .013, p < .05$ ]. However, this linear contrast on novelty scores did not approach significance ( $F < 1$ ). Thus, complexity of the old polygon affected recognition memory but not looking behavior in the VPC.

This double dissociation between VPC performance and recognition memory provides evidence against the explicit memory explanation for novelty preferences. A final way to examine this hypothesis is to test for a correlation between recognition memory performance and VPC task performance. Using the recognition memory data, we calculated the relative explicit “memorability” of the old polygons in each test pair. The explicit memory hypoth-

esis would be supported if the more readily memorable the old polygon of a test pair in the explicit memory task, the more looking takes place toward the novel polygon of that test pair in the VPC task (in the unconditioned, late time-window condition). In contrast with this prediction, no positive correlation was observed ( $r = -.01, p > .90$ ).

## DISCUSSION

The results reported here support the biased competition hypothesis of novelty preferences to a greater degree than they do the explicit memory hypothesis. First, learned salience of familiar stimuli affected looking behavior in the VPC, but not recognition memory, suggesting that looking behavior in the VPC and recognition memory are supported by different types of memory. Second, as predicted by the biased competition hypothesis, the typically observed novelty preference occurred only when the bias toward novelty had no competition. In contrast, when a form of learned salience occurred during initial exposures to the familiar stimuli, participants did not look longer at the novel stimuli at test. This suggests that learned salience of the familiar stimuli competed with the attentional bias toward novelty, eliminating the novelty preference. Third, we found that greater likability of the novel polygon, possibly indexing overlap with preexisting representations that makes the novel polygon more familiar, resulted in a weaker bias toward novelty, but did not affect recognition memory. Fourth, complexity of the polygons affected recognition memory but not novelty preferences, providing evidence that different variables had different effects on the two forms of memory in a double dissociation pattern. Fifth, we did not find a relation between the likelihood that a repeated polygon would be explicitly remembered and novelty scores in the VPC, a relation that would be expected if looking in the VPC were supported by explicit memory. This pattern of findings suggests that these two forms of memory are supported by different memory systems. Finally, we report for the first time that, within the time course of individual testing trials, participants tend to look first at familiar stimuli and then proportionally longer at novel stimuli later in the trials.

Taken together, the results reported here suggest that novelty preferences reflect attentional processes and implicit memory to a greater degree than they do explicit memory. It is possible that a single memory system could underlie both looking behavior and explicit memory (as in single-system accounts of implicit and explicit memory; e.g., Nosofsky & Zaki, 1998; Palmeri & Flanery, 1999), but single-system theories will need to be revised to account for the pattern of results reported here.

The present results have important implications for interpreting performance in the VPC accurately and, by extension, understanding memory development. Research with preverbal infants and experimental animals often utilizes the VPC as a nonverbal measure of memory (e.g., Nemanic et al., 2004; Rose, Feldman, & Jankowski, 2004). In fields such as these, where memory must be assessed using nonverbal measures, there is a great deal of debate over the types of representations and processes that sup-

port novelty preferences (e.g., Haith, 1998; Hood, 2004). Some researchers argue that novelty preferences reflect a form of explicit or declarative memory (McKee & Squire, 1993; Nelson, 1995; Rose et al., 2004), whereas others argue that novelty preferences reflect a more primitive form of memory that requires only perceptual facilitation (Mandler, 1988; Schacter & Moscovitch, 1984; Snyder, 2007). One implication of the former view is that infants may have conscious or voluntary access to their memory from birth, since infants as young as 3 days old show novelty preferences in the VPC (Pascalis & de Schonen, 1994). The data reported here, however, suggest that novelty preferences may reflect attentional biases and implicit memory to a greater degree than they do conscious, aware recognition. If so, there is no evidence for explicit memory in infants younger than 6 to 8 months of age, since the VPC is widely considered to be the only task able to provide such evidence in younger infants (but see Rovee-Collier, 1997). Thus, accurate interpretation of the VPC is crucial to our understanding of infant cognition and memory development and to our understanding of memory in nonverbal populations.

In addition, the biased competition model provides an explanation for performance in the VPC that is consistent at both the neural and cognitive levels. Recently, data from immediate early gene imaging studies in rodents indicate that familiar compared with novel objects elicit a *decrease* in neural activity in the perirhinal cortex and visual area TE, but no difference in hippocampal activity (e.g., Wan, Aggleton, & Brown, 1999; Zhu, Brown, McCabe, & Aggleton, 1995). These findings are consistent with electrophysiological evidence in humans (e.g., Begleiter, Porjesz, & Wang, 1993) and monkeys (e.g., Fahy, Riches, & Brown, 1993; Li, Miller, & Desimone, 1993; Miller, Gochin, & Gross, 1991), indicating that neurons in the perirhinal cortex and adjacent visual association areas respond less to visual stimuli that were previously encountered, a phenomenon known as *repetition suppression*. Importantly, that repetition suppression in the occipital-temporal visual processing pathway is thought to mediate the bias toward novelty in visual selective attention (Desimone, 1996). In theory, reduced activation to a repeated stimulus results in a smaller neural signal for familiar stimuli, biasing the competition for visual processing resources (and, hence, visual attention) toward novel stimuli when there are no other competing biases (such as from the learned importance of a stimulus). Since repetition suppression is an intrinsic property of the visual processing pathway and occurs independently of the hippocampus, an important implication of the biased competition model is that longer looking to a novel stimulus may be merely a consequence of reduced neural responses to previously encoded items; it may not require explicit awareness, voluntary or deliberate control, or even a comparison between new and previously encoded items. In the VPC, then, memory may have an indirect, incidental influence on looking behavior.

Given the important implications of our results and conclusion, further testing should be aimed at examining the effects of learned salience on novelty preferences in infants. On the basis of the findings presented here, we

would predict that conditioning would similarly modulate infants' novelty preferences. Such effects have not previously been examined in infants.

#### AUTHOR NOTE

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#### NOTES

1. As assessed and reported by Vanderplas and Garvin (1959a).
2. The positive IAPS slides were 4606, 4640, 4653, 4658, 4680, 5470, 5621, 5626, 8021, 8030, 8080, 8161, 8300, 8380, 8420, 8502. The negative IAPS slides were 3400, 2691, 9630, 6370, 9042, 6250, 3160, 3280, 6260, 6200, 9120, 1050, 9620, 9920, 6242, 9400.

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