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Roles of Object-File Review and Type Priming in Visual Identification Within and Across Eye Fixations

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Dynamic visual identification was investigated in 4 experiments. In Experiments 1 and 2, 2 perceptual objects (2 frames, each containing a letter or 1 containing a letter and the other a plus sign) were previewed in the periphery. A saccade brought these objects to central vision. During the saccade the display was changed so that 1 frame contained a letter and the other a plus sign, and the subject identified the letter by naming it aloud as rapidly as possible. In Experiment 3, the retinal events of Experiments 1 and 2 were simulated. In Experiment 4, both the preview and the target were presented centrally within a single fixation. In all experiments both object-specific and nonspecific preview benefits were observed. These results support a theory in which the preview benefits observed during visual identification arise from 2 processes, object file review and type priming.

Natural visual perception is a dynamic process involving movement of both the viewer and objects within the viewed scene. Despite these variations, it would be beneficial if the system devoted to object identification could use the information acquired during one glimpse to constrain its search of the potential object candidates it must consider during a subsequent glimpse. The question to be addressed in this paper, then, is: How does the identification system use the information obtained from an object at one place and one time to aid identification of that object when it is viewed again a short time later?

One way to explore dynamic object identification is to use a preview paradigm, where the presentation of a target object is preceded by a preview display that may or may not contain that target object. A measure of the preview benefit derived from an earlier glimpse of the target can be calculated by comparing identification latencies when a preview of the target is present in the preview display compared with when a preview is not present in the preview display (e.g., Henderson, 1992; Henderson, Pollatsek, & Rayner, 1987, 1989; Pollatsek, Rayner, & Collins, 1984; Pollatsek, Rayner, & Henderson, 1990; Rayner, McConkie, & Ehrlich, 1978; Rayner, McConkie, & Zola, 1980). The presentation of a preview of a target object could influence identification processes in a number of ways roughly mapping onto the types of representations that are functional during identification. Most theories of identification posit at least two types of representations: short-term, temporary representations constructed during the current perceptual episode (i.e., object tokens), and long-term, stable representations of previously experienced objects (i.e., object types). Recognition is then assumed to involve matching the short-term representation to the stored long-term representations until a match is found (e.g., Biederman, 1987; Marr, 1982; Yuille & Ullman, 1990).

On this generic view, preview benefits could arise from one or both of these representational systems. First, preview benefits could arise from an integration of information across views at the level of the temporary episodic representation. That is, presentation of the preview could cause the creation of a temporary representation that would maintain information about objects viewed during the current perceptual episode. A framework for thinking about episodic integration is provided by the object files theory (Kahneman & Treisman, 1984; Kahneman, Treisman, & Gibbs, 1992). According to this theory, a temporary representation (object file) is initially established for each visible object. Object files contain information about the object, such as its perceptual features and its identity (if known). When a change is detected, the visual system attempts to determine whether a new object is present or an old object has changed. To do this, the system uses a correspondence process that is based on spatiotemporal continuity to address the file; it does not use form or identity. When correspondence is found, a reviewing process retrieves the information contained in the file, and if that information matches the current stimulus, identification will be facilitated.

A second potential source of preview benefits is the activation of long-term representations of object types. For

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example, if representations of object types are conceived of as nodes in a network, then preview benefits could be due to priming these nodes. Pollatsek and colleagues (1990) proposed that preview benefits observed across eye fixations might be due to such priming. In contrast to preview benefits arising from integration within object files, this type of priming would be independent of spatial or spatiotemporal continuity, because object types by definition do not include information about the time or place of a particular perceptual episode. According to this theory, preview benefits may arise from activation of type information at several levels of representation, including the level devoted to recognition (e.g., a network of representations of shape) as well as a semantic or conceptually based system. Similarly, Kahneman et al. (1992) suggested that priming of long-term representations may contribute to preview benefits.

A key diagnostic for determining whether the preview benefits observed in a given experimental situation are due to the reviewing of object files or priming of object types is the degree to which those preview benefits are tied to the spatiotemporal continuity of the object. Preview benefits due to integration within an object file should be constrained by continuity, whereas preview benefits due to type activation should not. Evidence suggests that both types of preview benefits can be observed, depending on the circumstances.

In one series of experiments designed to determine the level at which preview benefits are produced, Pollatsek et al. (1990) presented subjects with a preview display containing either two line drawings of natural objects or one line drawing and one empty frame. The objects were presented in the visual periphery, and the subject was instructed to execute a saccade toward them as soon as they appeared. During the saccade, the display was changed so that a single target object was present when the eyes landed. The subject's task was to name the target object as quickly as possible. Large preview benefits were obtained in these experiments when the target object had been contained in the first display compared with when it had not. Furthermore, most of the preview benefit was independent of the preservation of spatiotemporal continuity. The preview benefit was 10 ms and 13 ms larger when the target remained in the same location than when it switched location in the two experiments. In contrast, the continuity-independent benefit observed when the target switched location was 55 ms and 71 ms in the two experiments. Thus, although there was some evidence for the role of object files in producing the transsaccadic preview benefit, the majority of benefit appeared to be due to type priming.

Pollatsek et al. (1990) also included two control experiments in which no intervening saccade occurred between preview and target displays, though the duration of the preview display was about the same as in the saccade experiments (200 ms). In the first control experiment, the retinal events of the eye-movement experiments were duplicated by presenting the preview objects peripherally and the target object centrally. In that experiment, there was again a large continuity-independent benefit of 46 ms, but no additional benefit when the target remained in the same location compared with when it switched location (in fact, there was inexplicably more benefit when the target switched location than when it did not). In the second control experiment, both the preview and target objects were presented centrally. The results suggested both continuity-dependent (40 ms) and continuity-independent (48 ms) components to the preview benefit.

In a recent series of experiments similar in spirit to those of Pollatsek et al. (1990), Kahneman et al. (1992) presented subjects with a number of frames in the visual field, some containing letters and others empty. The letters then disappeared for a short time while the frames remained. Finally, a single target letter was presented in one of the frames, and the subject named the letter as quickly as possible. The main findings were somewhat different from those of Pollatsek et al. (1990). Although a preview benefit was obtained for a target letter if it appeared in the same frame as it had been in during the first display compared to a no-preview control, little or no such benefit was obtained when the target appeared in a different frame. This basic pattern held across a large number of experiments and conditions and suggested to Kahneman et al. that their preview benefits were almost exclusively due to integration at the level of spatiotemporally addressed object files. Still, as Kahneman et al. pointed out, some evidence for preview benefits was occasionally observed even when continuity was violated, suggesting that type priming may sometimes play a role in producing preview benefits.

At one level, the Pollatsek et al. (1990) and Kahneman et al. (1992) studies are consistent in that they show some continuity-based preview benefit and some preview benefit independent of continuity. However, the degree to which the preview benefits were dependent on continuity differed widely. Succinctly, most of the preview effects were continuity independent in the Pollatsek et al. experiments and continuity dependent in the Kahneman et al. experiments. Two questions arise from this observation. First, are the processes that give rise to continuity-dependent and continuity-independent preview benefits mutually exclusive, perhaps due to a process of mutual inhibition, or can they act in concert? Second, what accounts for the relative contributions of these two types of representations? These questions are important because determining when preview benefits are and are not continuity dependent may indicate when object files and type priming influence dynamic visual recognition. On the basis of the Pollatsek et al. results, it could be that object files play little role in transsaccadic identification. On the other hand, it could be that other methodological differences account for the relatively small effects of continuity in the transsaccadic experiments reported by Pollatsek et al. (1990).

A number of methodological differences were identified by Kahneman et al. (1992) that might have accounted for the large degree of continuity dependence that they observed. First, Pollatsek et al. (1990) used a pattern mask at the nontarget location following the preview, whereas Kahneman et al. did not. Kahneman et al. suggested that the appearance of the mask may have provided the visual system with some evidence that the target object had moved when the preview and target appeared at different locations. If linking motion was perceived when the target switched location, then spatiotemporal continuity would have been maintained, and the apparent continuity-independent benefit observed in the switch condition would actually be continuity-dependent benefit. Second, Pollatsek et al. used a larger set of stimuli and fewer repetitions than did Kahneman et al. The large number of repetitions in the Kahneman et al. study may have saturated the type representations with activation over trials, leaving little room for trial-to-trial variation and hence a reduced type priming effect. Third, Pollatsek et al. used line drawings of real-world objects as targets, whereas Kahneman et al. used alphabet characters. It could be that objects are generally more susceptible to type priming than are letters in producing preview benefits.

There are at least two other differences between the Kahneman et al. (1992) and Pollatsek et al. (1990) studies that could have contributed to the differences in results. First, Kahneman et al. provided frames at each potential object location during the preview display, the intervening display (containing empty frames), and the target display. Because a given set of frames was always present, it could be that they served to help maintain spatiotemporal continuity and hence fostered the use of object files. Second, the changes in location in the Pollatsek et al. study were relatively small (about 2.5°), whereas they tended to be larger in the Kahneman et al. study. It could be that location information is coded fairly coarsely during brief exposures. The difference in results might then reflect the degree to which this coarse coding would lead to different location representations for the objects, with the two objects in the Pollatsek et al. study coded at the same location and the objects in the Kahneman et al. study coded at different locations. If the two objects were coded at the same location in the Pollatsek et al. study, then spatiotemporal continuity would be maintained even when the objects in fact changed location.

Finally, Pollatsek et al. (1990) focused on transsaccadic preview benefits whereas Kahneman et al. (1992) focused on within-fixation benefits. At first glance, this difference might be thought to account for the differing results: Other studies that have explored the role of spatiotemporal continuity on preview benefits across eye fixations have provided evidence that these benefits are often independent of the maintenance of spatial location. For example, O'Regan (1981) found that the line of text that a subject was reading could be shifted several character spaces during a saccade with very little effect on reading speed or comprehension. These shifts of the text caused letters to replace other letters and parts of words to replace parts of other words at each spatial location. In these experiments, subjects did not perceive any motion that might link the words together across the fixation, and often did not realize that a change had occurred. Similar results have been obtained when scenes are spatially displaced up to one-third the distance of the saccade (Bridgeman, Hendry, & Stark, 1975). If preview benefits for these stimuli were dependent on spatiotemporal continuity for successful integration, then the shifts should have resulted in severe disruption. The absence of disruption despite these location changes seems to indicate that object files play a minor role across fixations. However, it is important to note that in these displacement studies the entire line of text or image moved. Thus, if location is coded in relative rather than absolute coordinates, object continuity could have been maintained.

Furthermore, it is unlikely that the difference in results in the Kahneman et al. (1992) and Pollatsek et al. (1990) studies was due to the absence versus presence of saccades: As discussed above, in one of the Pollatsek et al. within-fixation control studies, no evidence was found for continuity-dependent benefit. Although Kahneman et al. did not monitor eye fixations, many of their experiments included conditions with display durations long enough for several eye fixations to take place, yet their continuity-dominant pattern of results was still obtained. Clearly, then, the presence of saccadic eye movements is not the sole factor determining when preview benefits will be dominantly continuity dependent versus dominantly continuity independent.

Present Study

In the present study, our purpose was to investigate further the nature of preview benefits during visual object identification. Our main focus was the relative contributions of temporary object files and long-term object types to preview benefits in visual identification. We were particularly interested in determining whether we could provide clear evidence for the use of object files in producing preview benefits during transsaccadic identification. These issues were explored by measuring preview benefits during letter identification following a large change in both absolute and relative spatial location from Time 1 to Time 2 with no perceptual motivation for such a change.

The basic paradigm used in these experiments was a hybrid of those used by Pollatsek et al. (1990) and Kahneman et al. (1992). In Experiments 1 and 2, two perceptual objects (two frames, each containing a letter or one containing a letter and the other a task-irrelevant plus sign) were presented in the periphery. A saccade then brought these objects to central vision. During the saccade the display was changed so that one frame always contained a letter (the target) and the other a plus sign. The subject identified the target letter by naming it aloud as rapidly as possible. Naming latency was used to reflect identification latency. In Experiment 3, the retinal events of Experiments 1 and 2 were simulated by displaying the preview peripherally and the target centrally within a single fixation. In Experiment 4, the same perceptual objects were displayed around the fixation point within a single fixation. Following Kahneman et al. (1992), we focussed on two types of preview benefits across the four experiments. The *object-specific benefit* was defined as the preview benefit that required the target to appear in the same frame as had the preview, whereas the *nonspecific benefit* was defined as the preview benefit that survived a change in spatiotemporal continuity. The object-specific benefit is assumed to reflect integration within object files; the nonspecific benefit is assumed to reflect type priming.

In addition to the manipulation of spatiotemporal continuity, we also manipulated the number of potentially task-relevant objects present in the preview display. This manipulation should provide us with converging evidence that the object specific component is due to object file review whereas the nonspecific component of the preview benefit is due to type priming. The hypothesis is that the construction and reviewing of object files is a capacity-limited operation (Kahneman et al., 1992), whereas priming long-term memory representations of letters from their visual forms should be relatively automatic. Therefore, the prediction is that the object-specific component of the preview benefit will be more influenced by the number of letters present in the preview display than will the nonspecific component.

Experiment 1

In Experiment 1, we used a saccade-contingent display change technique. Each trial consisted of three display events, as depicted in Figure 1. First, a fixation field was presented, consisting of three fixation markers. The subject began each trial by fixating the left-most marker. Second, a preview field was shown, consisting of two frames containing two letters or a letter and a plus sign. The subject was instructed to execute a saccade to a location between the two frames as quickly as possible once they were presented. Third, when the computer detected the execution of a saccade, a target field was displayed, consisting of the same two frames containing the target letter and a plus sign. The subject named the target letter as quickly as possible following the saccade.

To examine the role of spatiotemporal continuity on the ability of the identification system to use the information contained in the preview field, we included six preview conditions consisting of the 3 × 2 factorial combination of the spatiotemporal continuity (henceforth, continuity) of the target relative to the preview, and the type of flanker object shown with the preview. The three levels of the continuity factor were: *same-frame,* in which the target letter remained in the same frame from preview to target field; *switch-frame,* in which the target letter switched to the other frame from preview to target field; and *control,* in which no preview of the target was shown in the preview field. The two levels of the flanker variable were: *letter,* in which another potential letter target appeared in the preview field along with the target; and *plus sign,* in which a nontarget plus sign appeared in the preview with the target.[1] We had subjects participate in two identical blocks of trials so that we could determine whether preview benefits not tied to continuity would decrease with practice, as suggested by the hypothesis that general activation plays less of a role once the type representations are saturated.

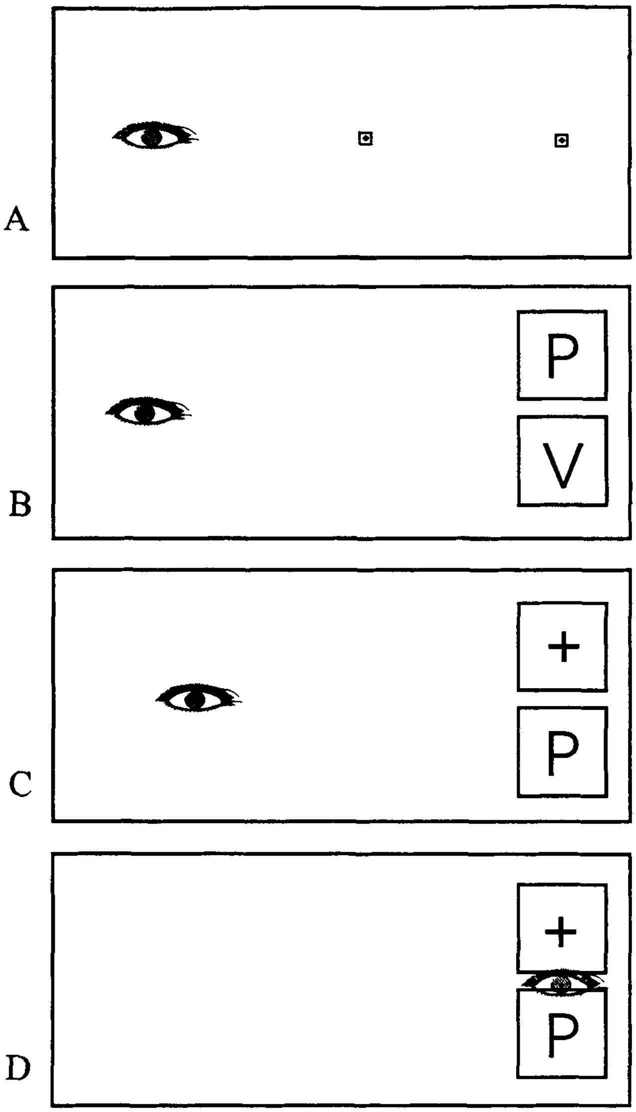

Figure 1. Schematic illustration of the displays presented during Experiment 1. Panel A: Three fixation markers were displayed, and the subject fixated the leftmost marker. Panel B: A preview display appeared. Panel C: The subject executed a saccade to a location between the two frames as quickly as possible, and during the saccade, a target display appeared containing a single target letter. Panel D: The subject named the target letter following the saccade.

The main purpose of Experiment 1 was to determine whether a clear effect of continuity, and hence clear evidence for the use of object files, could be observed in a transsaccadic preview benefit paradigm. To this end, we made several modifications to the original Pollatsek et al. (1990) paradigm to increase the likelihood that subjects would construct and use object files during the task. First,

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[1] We chose to include a plus sign in the preview displays that did not include a letter flanker rather than using an empty box because we wanted to ensure that the abrupt onset in the two locations would be roughly equated. Otherwise, we were concerned that given one box containing a letter and another empty box, attention would be drawn exogenously to the letter.

we increased the distance between the locations of the two objects to better approximate the 8.9° matrix used by Kahneman et al. (1992) in their Studies 1 and 2 (the studies that did not include object motion). Second, we surrounded each of the potential target locations with frames in the preview and target displays. Third, we did not use a mask at the nontarget location in the target display; instead, we presented a plus sign along with the target. Fourth, we used as targets eight of the nine letters used by Kahneman et al. in their Studies 1 and 2. Finally, the two preview locations were arranged one above the other rather than side-by-side as they had been in the Pollatsek et al. (1990) study. We decided to change to the vertical arrangement because in the Pollatsek et al. experiments, there was a tendency for the initial fixation following the saccade to the target display to land on the closer object, and there was also a tendency for a greater preview benefit to be derived from the closer of the two locations. By using the vertical arrangement, we hoped to circumvent the problems of interpretation caused by these tendencies.

Method

Subjects. Twelve members of the University of Alberta subject pool participated in the experiment for course credit. All subjects had normal vision or wore contact lenses. The subjects had not participated in previous eye-movement experiments and were naive with respect to the hypotheses under investigation.

Stimuli. The target stimuli were the capital letters *C, K, L, M, P, S, T,* and *V.* Each preview and target display contained two frames. Within each frame appeared either a letter or a plus sign. The frames subtended 5.1° vertically and 4.8° horizontally, with .95° separating the frames. The letters and the plus sign were about 2.4° in height and 1.9° in width. There was a 6° separation between the centers of the stimuli (letters and plus signs) across frames, and 3.6° between their nearest contours.

Sixteen target displays were used, consisting of each of the eight letters in each of the two (top and bottom) frames. A plus sign occupied the frame not occupied by the target letter in each target display. In addition, there were 33 preview displays. Sixteen of these preview displays were identical to the target displays and comprised the same-frame plus-flanker and switch-frame plus-flanker conditions. For example, a *C* above a plus sign would serve as the same-frame plus-flanker preview for the *C* target appearing in the top frame, and as the switch-frame plus-flanker for the *C* target appearing in the bottom frame. An additional 16 displays contained 2 letters each, 8 pairs of letters by 2 configurations (e.g., *P* above *V* and *V* above *P*). These displays were used in the same-frame letter-flanker condition, the switch-frame letter-flanker condition, and the letter-flanker control conditions. For example, the display containing a *P* in the top frame and a *V* in the bottom frame served as the preview for the same-frame letter-flanker condition when the *P* appeared as the target in the top frame and when the *V* appeared as the target in the bottom frame. This same display served as the preview for the switch-frame letter-flanker condition when the *P* appeared as the target in the bottom frame and when the *V* appeared as the target in the top frame. This display also served as the letter-flanker control when the *C* appeared as the target in the top frame. (The letter-flanker control for the *C* when it appeared as the target in the bottom frame was *V* above *P*.) Note that with this design, a given letter in a given frame in the preview display was equally predictive of itself and of two other letters as the target in that same frame. Finally, a display consisting of a plus sign in each frame served as the preview display for the plus-flanker control condition. Figure 2 shows the six preview displays when the target letter *C* appeared as the target in the top frame.

Apparatus. The stimuli were displayed at a resolution of 640 × 200 pixels on a Zenith flat-screen videographics array monitor, with the contours of the letters and frames appearing black (pixels off) against a white (pixels on) background.

Eye movements were monitored through an ISCAN RK-416 high-speed eyetracker. The eyetracker and display monitor were interfaced with an 80386-based microcomputer that controlled the experiment. The computer recorded saccade latencies and naming latencies. Signals were generated by the eyetracker at a frequency of 120 Hz, and the computer changed the display contingent on detecting an eye movement of greater than 0.5°. Because a saccade directed to a target 20° away requires well over 50 ms, the display change was accomplished during the saccade when vision was suppressed.

Procedure. On arriving for a session, each subject was seated comfortably with his or her head resting on a chin and forehead rest to minimize head movements. The calibration of the eyetracker then took place. After calibration, subjects participated in one practice block of 16 trials and two test blocks of 96 trials each. A trial consisted of the following events. First, a fixation display appeared containing three test fixation markers and a small cross that indicated the computer's estimate of the current fixation position. The subject fixated each test marker, and if the calibration was satisfactory (plus or minus .33° from each marker), the experimenter asked the subject to fixate the left-most marker to indicate readiness to begin the trial. The experimenter then initiated the trial by pushing a silent button. The fixation display was replaced by a preview display consisting of two frames to the right of fixation, each containing a letter or one containing a letter and the other a plus sign. The subject immediately initiated a rightward horizontal eye movement to a location centered between the two frames.[2] The distance from the initial fixation point to the location centered between the two frames was 20.6°. During the saccade, the preview display was replaced by the target display, consisting of the target letter in one frame and a plus sign in the other. The target display remained in view until the subject responded by naming the target letter as quickly as possible. The computer recorded the latency of the eye movement and the latency of the vocal response (timed from when the eye crossed the 0.5° boundary).

Each subject participated in two blocks of trials. In the first block, the subject saw all 96 trials in a pseudorandom order. After a short rest, the subject received the second block, which consisted of the same trials in a new pseudorandom order. In each block, the 96 trials were produced by the within-subjects factorial combination of 8 (target letters) × 2 (target positions: top and bottom) × 2 (flanker conditions: plus and letter flankers) × 3 (continuity conditions: same-frame, switch-frame, and control). The experiment was completed in a single session that lasted about 45 min.

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[2] In the Pollatsek et al. (1990) study, subjects executed both leftward and rightward saccades to the targets. The direction of the saccade made no difference in those experiments (see also Henderson, Pollatsek, & Rayner, 1987; Pollatsek, Rayner, & Collins, 1984) and therefore was not included in the design of the current experiment.

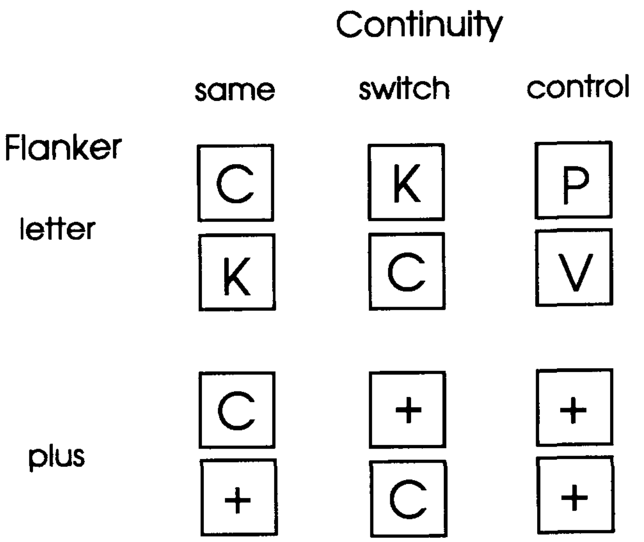

Figure 2. Schematic illustration of the previews for the six conditions (3 flanker conditions × 2 continuity conditions), given that the target was the letter *C* in the top frame.

Results

Mean corrected naming latencies collapsed over block and target position are presented in Table 1. These means exclude trials on which an anticipatory eye movement occurred (defined as a saccade with a latency of less than 100 ms) and trials on which the naming latency was less than 200 ms, more than 1,500 ms, or greater than 3 standard deviations from the mean naming latency for that subject. About 6% of the data was eliminated in total. The pattern of corrected latencies did not differ from the pattern prior to correction. Overall, mean eye-movement latency was 217 ms (216 ms in Block 1 and 218 ms in Block 2) and was not mediated by any of the experimental factors (all $ps > .25$).

The four within-subject factors of target position, flanker type, continuity, and block were entered into an analysis of variance (ANOVA). Naming latencies were 59 ms faster in the plus-sign flanker condition (565 ms) than in the letter-flanker condition (624 ms), $F(1, 11) = 75.06$, $p < .001$, $MS_e = 3{,}337$. As can be seen in Table 1, there was a main effect of continuity, with mean naming latencies of 557 ms, 598 ms, and 630 ms in the same-frame, switch-frame, and control conditions, respectively, $F(2, 22) = 75.13$, $p < .001$, $MS_e = 1{,}748$. Planned comparisons showed that naming latencies in the same-frame condition were faster than in the control condition, $F(1, 11) = 94.38$, $p < .001$, $MS_e = 2{,}771$; latencies in the switch-frame condition were faster than in the control condition, $F(1, 11) = 32.51$, $p < .001$, $MS_e = 1{,}583$; and latencies in the same-frame condition were faster than those in the switch-frame condition, $F(1, 11) = 91.08$, $p < .001$, $MS_e = 889$. The block factor did not interact with flanker, $F(1, 11) = 2.828$, $p > .10$, $MS_e = 823$; with location, $F(2, 22) < 1.0$, $MS_e = 805$; or with the combination of the two, $F(2, 22) = 1.269$, $MS_e = 1{,}988$.

Table 1 also shows the object-specific and nonspecific components of the preview benefit. The nonspecific benefit was computed as the difference between the control and switch-frame conditions, and the object-specific benefit was computed as the difference between the switch-frame and same-frame conditions (Kahneman et al., 1992). Although it appears that the object-specific component was more influenced by the flanker manipulation, the Flanker Type × Continuity interaction did not reach significance, $F(2, 22) = 2.299$, $p = .12$, $MS_e = 2{,}851$. However, examining each component separately revealed that the nonspecific benefit was unaffected by flanker type ($F < 1$), and the influence of flanker type on the object-specific component was marginal, $F(1, 11) = 3.947$, $p < .10$, $MS_e = 2{,}105$.

Finally, there was a marginal Block × Target Position × Flanker interaction, $F(1, 11) = 4.639$, $p < .10$, $MS_e = 1{,}254$. Naming latencies were slightly faster when the target appeared in the bottom versus the top frame following either a letter or a plus-sign flanker in Block 2 (4 ms and 15 ms, respectively) and following a letter flanker in Block 1 (7 ms), but were slightly slower when the target appeared in the bottom frame given a plus-sign flanker in Block 1 (18 ms). This marginal interaction does not have any apparent explanation and does not appear to be of theoretical importance. The target position factor did not produce a main effect and did not interact with any other factor ($ps > .20$).

Discussion

The results of this experiment showed a robust preview benefit. Naming latencies were faster when a preview of the target object was available than when a preview was not available. It is important to note that preview benefits were observed both when the target remained within the same frame from preview to target display and when the target switched to a new frame across displays. Thus, the pattern of results is consistent with the notion that transsaccadic preview benefits are produced by two general mechanisms, one affected by the spatiotemporal continuity of the object and the other independent of continuity.

A related finding was that a preview benefit was obtained in the switch-frame condition whether or not the target letter switched to become part of a frame that had previously contained a different letter. The effect of switching into the frame previously occupied by another potential target pro-

Table 1

Mean Naming Latencies and Mean Preview Benefits (in Milliseconds) as a Function of the Continuity of the Target Relative to the Preview and the Type of Flanker Presented in the Preview: Experiment 1

	Continuity			Preview benefit	
Flanker type	Same	Switch	Control	Object specific	Nonspecific
Letter	596	623	654	27	31
Plus	518	572	607	54	35
M	557	598	630		

duced quantitatively the same level of disruption as did switching into the frame occupied by a nontarget stimulus (the plus sign). This result is consistent with the hypothesis that the benefit in the switch condition reflects activation of long-term representations. On the other hand, the presence of a letter flanker had a marked effect on the preview benefit observed in the same-frame condition; the preview benefit was larger when the flanker was an irrelevant plus sign than when it was a potentially relevant letter. Although this result did not reach statistical significance, it was replicated across experiments, as will be seen below. If the object-specific benefit reflects the integration of information in object files, then this result supports the hypothesis that there is a cost associated with constructing, maintaining, or reviewing multiple object files.

The results of Experiment 1 provide no evidence for the hypothesis that preview benefits would become more object specific as the number of trials with the target letters (and hence the level of semantic activation for the long-term representations coding those letters) increased. The pattern of results was very similar across the two blocks of trials, and there was no indication that the magnitude of the nonspecific preview benefit was reduced from the first to the second block: In Block 1, the object specific and nonspecific preview benefits were 40 ms and 33 ms, respectively, whereas in Block 2 these preview benefits were 42 ms and 33 ms, respectively.

In summary, the results of Experiment 1 are consistent with both object-file review and type priming. A brief preview of a target object at Time 1 can produce significant benefits on target identification at Time 2 despite a violation of spatiotemporal continuity, consistent with Pollatsek et al. (1990), but greater preview benefit was observed in the same-frame than switch-frame condition, consistent with the findings of Kahneman et al. (1992). These data suggest that both object-file review and object-type priming can simultaneously contribute to the preview benefit observed during transsaccadic identification.

Experiment 2

We have assumed that a preview benefit was observed in the switch-frame condition of Experiment 1 because the preview primed long-term representations. Another possibility is that the letter positions were similar enough that they were identically coded. Therefore, in Experiment 2 we sought to replicate the results of Experiment 1 with an even greater change in the absolute location of the target letters in the switch-frame condition. We increased the distance between the letters from 6° to 10° center-to-center and from 3.6° to 7.5° from nearest contours. In order to increase this distance, we increased the size of the frames within which the letters appeared. The letters themselves, however, remained the size they had been in Experiment 1.

Method

Subjects. Ten members of the Michigan State University subject pool participated in the experiment for course credit. All subjects had normal vision or wore contact lenses. The subjects had not participated in previous eye-movement experiments and were naive with respect to the hypotheses under investigation.

Stimuli, apparatus, and procedure. The stimuli, apparatus, and procedure were identical to those used in Experiment 1, with the following exceptions. First, the frames surrounding the letters and plus signs were increased in size to 7.3° horizontally and 8.3° vertically. The distance between the nearest contours of the frames remained .95°. The letters and plus signs were centered within the new frames, so that there was about 10° between the centers of these stimuli and about 7.6° between their nearest contours. Second, each subject participated in only one block of 96 trials. The experiment was conducted in a single session that lasted less than 30 min.

Results

Mean corrected naming latencies collapsed over target position are presented in Table 2. These means exclude trials on which an anticipatory eye movement occurred (defined as a saccade with a latency of less than 100 ms) and trials on which the naming latency was less than 200 ms, more than 1,500 ms, or greater than 3 standard deviations from the mean naming latency for that subject. About 7% of the data was eliminated in total. The pattern of corrected latencies did not differ from the pattern prior to correction. Eye-movement latency was 242 ms and was not mediated by any of the experimental factors (all *p*s $> .20$).

The three within-subject factors of target position, flanker type, and continuity were entered into an ANOVA. First, naming latencies were 51 ms faster in the plus-flanker condition (554 ms) than in the letter-flanker condition (605 ms), $F(1, 9) = 20.25$, $p < .005$, $MS_e = 3{,}854$. Second, as can be seen in Table 2, there was a main effect of continuity, with mean naming latencies of 541 ms, 583 ms, and 616 ms in the same-frame, switch-frame, and control conditions, respectively, $F(2, 18) = 24.88$, $p < .001$, $MS_e = 2{,}280$. Planned comparisons showed that naming latencies in the same-frame condition were faster than in the control condition, $F(1, 9) = 33.17$, $p < .001$, $MS_e = 3{,}401$; naming latencies in the switch-frame condition were faster than in the control condition, $F(1, 9) = 12.90$, $p < .01$, $MS_e = 1{,}652$; and naming latencies in the same-frame condition were faster than in the switch-frame condition, $F(1, 9) = 20.17$, $p < .005$, $MS_e = 1{,}787$.

A marginal Flanker Type × Continuity interaction was found, $F(2, 18) = 3.390$, $p < .10$, $MS_e = 1{,}560$. Examining

Table 2
Mean Naming Latencies and Mean Preview Benefits (in Milliseconds) as a Function of the Continuity of the Target Relative to the Preview and the Type of Flanker Presented in the Preview: Experiment 2

Flanker type	Continuity: Same	Continuity: Switch	Continuity: Control	Preview benefit: Object specific	Preview benefit: Nonspecific
Letter	579	604	633	25	29
Plus	502	563	598	61	35
M	541	583	616		

the object-specific and nonspecific components separately (shown in Table 2) revealed that the nonspecific benefit was unaffected by flanker type, $F < 1$, whereas the object-specific component was influenced by the flanker, $F(1, 9) = 10.31$, $p < .05$, $MS_e = 636$.

The position of the target also affected naming latencies. There was a marginal main effect of target position, with latencies for targets appearing in the top location 16 ms faster than for targets appearing in the bottom location, $F(1, 9) = 4.426$, $p < .10$, $MS_e = 1{,}794$. In addition, target position interacted with flanker type, $F(1, 9) = 5.946$, $p < .05$, $MS_e = 690$, and with continuity, $F(2, 18) = 5.324$, $p < .05$, $MS_e = 2{,}274$. These lower order effects were mediated by a three-way Target Position × Flanker Type × Continuity interaction, $F(2, 18) = 4.854$, $p < .05$, $MS_e = 948$. The nature of this interaction is shown in Figure 3. As can be seen, when a plus flanker was present in the preview display, both object-specific and nonspecific preview benefits were observed regardless of target position. In contrast, when a letter flanker was present, object-specific preview benefit dominated when the target appeared in the top position and nonspecific preview benefit dominated when the target appeared in the bottom position. This interaction may be accounted for by assuming that subjects attended to and therefore acquired more information from the sole visible letter (irrespective of position) when it appeared with a plus sign in the preview display, but attended to the top letter when two letters appeared in the preview display. We return to this result in the General Discussion section.

Discussion

The results of this experiment showed a robust preview benefit both when spatiotemporal continuity was maintained and when it was not. The preview benefit in the switch-frame condition was obtained despite a 10° change in absolute position (center to center) and regardless of whether the target letter appeared within a frame that had previously contained a different letter. Again, however, the preview benefit was larger when continuity was maintained. The results involving flanker type and object continuity also replicated those of Experiment 1. The nonspecific preview benefit was largely unaffected by the presence of a flanker letter, whereas the object-specific preview benefit was reduced by the presence of the letter flanker.

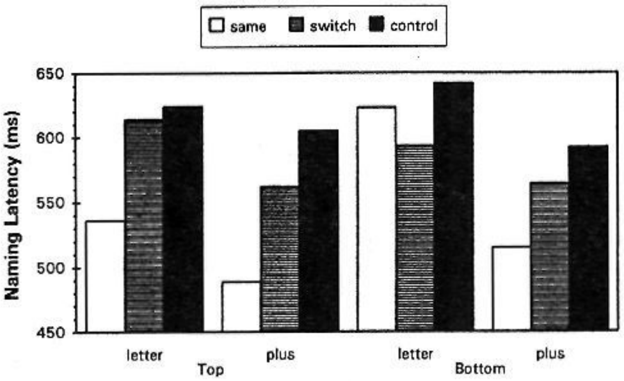

Figure 3. Naming latencies (in milliseconds) as a function of flanker, continuity, and position of target, Experiment 2.

The results of Experiments 1 and 2 support three conclusions. First, it is possible to observe large object-specific preview benefits across eye fixations, suggesting that integration within object files plays a role in transsaccadic identification. Second, it is possible to observe significant nonspecific preview benefits at the same time that object-specific benefits are observed. Thus, it appears that object files and object types work in concert to produce preview benefits. Third, we have provided evidence that a third factor, the presence or absence of a potentially task-relevant flanker, differentially affects the two components of the preview benefit, providing converging evidence that these two components reflect the operation of two separate representational systems.

In contrast to our results, Kahneman et al. (1992) found very small and in some cases no significant preview benefit when spatiotemporal continuity was violated using stimuli similar to those used here. One prominent difference between our experiments and those of Kahneman et al. is the involvement of an intervening saccade between preview and target displays in our experiments. It is possible that within a fixation, preview benefits are more reliant on object files, whereas across fixations, preview benefits are more reliant on type priming. The purpose of Experiments 3 and 4 was to test this possibility by examining within-fixation preview benefits using the stimulus displays that were used in Experiment 1.

Experiment 3

In Experiment 3, we presented subjects with a within-fixation version of Experiment 1. The preview display was shown in the periphery, and then the target display was presented at fixation. Thus, in Experiment 3 the retinal coordinates of the stimulus configuration were identical to those used in Experiment 1 (peripheral preview and central target); the environmental coordinates of the configuration changed from preview to target in Experiment 3 where they remained fixed in Experiment 1. The preview display was shown for 200 ms, followed by a 50-ms display of an empty field (an intervening display), followed by the target display. The duration of the preview display was approximately the mean duration that the preview display was seen in Experiment 1 (due to the 217-ms saccade latency). The purpose of the intervening display was to mimic the duration of the saccade in the first two experiments.

Method

Subjects. Ten members of the Michigan State University subject pool participated in the experiment for course credit. All subjects had normal or corrected vision. The subjects had not participated in either Experiment 1 or 2 and were naive with respect to the hypotheses under investigation.

Stimuli and apparatus. The stimuli and apparatus were identical to those used in Experiment 1, with the exception that the eyetracker was not used, and a blank intervening field was shown for 50 ms between presentation of the preview and target displays. This intervening field was white (all pixels on). The same computer and display monitor were used, and the eyetracker was in its usual position but was not turned on.

Procedure. The procedure was similar to that used in Experiment 1, except that the eyetracking component was removed. Subjects again used the chin and forehead rest to minimize head movements and maintain viewing distance. Subjects participated in one practice block of 18 trials and two test blocks of 96 trials each. A trial consisted of the following events. First, a fixation display appeared containing a single fixation point in the center of the screen. The statement "Press the button for the next trial" appeared in red on the monitor. When the subject was ready, he or she fixated the fixation point and pressed a button to begin the trial. The message was then removed, and 1 s later the preview display replaced the fixation display. The preview display was shown for 200 ms, then replaced with the intervening display for 50 ms, and finally the target display appeared. The target display remained in view until the subject responded. The subject was instructed to name the target letter as quickly as possible. The computer recorded the latency of the vocal response (timed from the generation of the y-sync pulse for the screen write that initiated display of the target). The statement "Press the button for the next trial" then reappeared, and the subject initiated the next trial.

Each subject participated in two blocks of trials with the same structure as Experiment 1. The experiment was completed in a single session that lasted about 30 min.

Results

Mean corrected naming latencies collapsed over target position are presented in Table 3. These means exclude trials on which the naming latency was less than 200 ms, more than 1,500 ms, or greater than 3 standard deviations from the mean naming latency for that subject. About 4% of the data were discarded by the naming latency correction. The pattern of corrected latencies did not differ from the pattern prior to correction.

The four within-subject factors of target position, flanker type, continuity, and block were entered into an ANOVA. Naming latencies were 11 ms faster when the target appeared at the bottom versus the top position (495 ms vs. 506 ms, respectively), $F(1, 9) = 5.252$, $p < .05$, $MS_e = 1{,}349$, and 29 ms faster in the plus-sign flanker condition (486 ms) than in the letter-flanker condition (515 ms), $F(1, 9) = 28.64$, $p < .001$, $MS_e = 1{,}740$.

Table 3
Mean Naming Latencies and Mean Preview Benefits (in Milliseconds) as a Function of the Continuity of the Target Relative to the Preview and the Type of Flanker Presented in the Preview: Experiment 3

Flanker type	Continuity			Preview benefit	
	Same	Switch	Control	Object specific	Nonspecific
Letter	503	512	529	9	17
Plus	462	488	507	26	19
M	482	500	518		

There was also a main effect of continuity (shown in Table 3), with mean latencies of 482 ms, 500 ms, and 518 ms in the same-frame, switch-frame, and control conditions, respectively, $F(1, 9) = 18.36$, $p < .001$, $MS_e = 1{,}379$. Planned comparisons showed that naming latencies in the same-frame condition were faster than in the control condition, $F(1, 9) = 27.19$, $p < .001$, $MS_e = 1{,}862$, latencies in the switch-frame condition were faster than in the control condition, $F(1, 9) = 6.999$, $p < .05$, $MS_e = 1{,}783$, and latencies in the same-frame condition were faster than in the switch-frame condition, $F(1, 9) = 26.08$, $p < .001$, $MS_e = 492$.

A marginal Flanker Type × Continuity interaction was found, $F(2, 18) = 2.500$, $p = .10$, $MS_e = 958$. Examining the object-specific and nonspecific components of the preview benefit separately (shown in Table 3) revealed that although the pattern was similar to that observed in Experiments 1 and 2, neither the nonspecific nor the object-specific component was influenced by the flanker, $F < 1$ and $F(1, 9) = 2.360$, $p > .10$, $MS_e = 1{,}268$, respectively.

Discussion

In Experiment 3, the same displays and similar timing parameters were used as had been used in Experiment 1. The major difference between the two experiments was that in Experiment 1 (and Experiment 2) an eye movement intervened between the preview and target displays, whereas in Experiment 3 the entire series of visual events appeared within a single fixation in order to simulate the retinal events of Experiments 1 and 2 without an intervening saccade. The results of Experiment 3 were remarkably similar to those observed in the first two experiments. First, a robust preview benefit was observed. Second, a nonspecific preview benefit was observed in the switch-frame condition that was unaffected by the presence of a flanker letter. Third, the object-specific preview benefit was smaller when a letter flanker was present in the preview than when it was not (9 ms vs. 26 ms, respectively), though this difference did not reach significance. Finally, and consistent with Experiment 1, we found no evidence that the preview benefit becomes more object specific over blocks.

The presence of an effect of continuity in this experiment is interesting and somewhat unexpected because in some sense, spatiotemporal continuity was violated in all conditions. That is, even in the "same-frame" condition, the objects in the preview display appeared 20° away from the frames in the target display. Thus, the "switch" that occurred was relative to the stimulus configuration rather than to absolute retinal or environmental coordinates. The finding of an effect of continuity, then, suggests that the continuity that controls the reviewing process for object files is partially defined by relative stimulus configuration rather than absolute spatial coordinates.

Experiment 4

In Experiments 1 and 2, the environmental coordinates of the two perceptual objects presented to the subject remained constant from preview to target display, whereas the retinal coordinates changed because of the intervening saccade. In Experiment 3, both the retinal and environmental coordinates changed from preview to target display. In both of these cases, the results were remarkably similar in showing both object-specific and nonspecific preview benefits. However, these cases differed from those used by Kahneman et al. (1992), where both the retinal and environmental coordinates of the perceptual objects remained constant or changed through apparent motion from preview to target displays, and where nonspecific effects were small or nonexistent. It is possible that a perceptually unmotivated change in either retinal or environmental coordinates causes a breakdown of the location information attached to the objects, leading to the greater level of nonspecific preview benefits that we have found (though again, Pollatsek et al., 1990, found evidence for nonspecific preview benefits at fixation). Furthermore, in the Kahneman et al. experiments that did not involve motion, the frames that partly defined each perceptual object remained visible throughout the trial. In our experiments, an interval of time intervened between preview and target display during which the frames were not visible, either due to the saccade (Experiments 1 and 2) or because we deliberately inserted a blank screen (Experiment 3). It could be that when a blank interval is inserted, subjects are more likely to experience linking motion when the target switches frames. Without the blank interval, on the other hand, explicit evidence exists that the objects have not moved. Therefore, in Experiment 4 we examined preview benefits using the same stimuli and timing parameters as had been used in Experiments 1 and 3, but we presented the two perceptual objects to central vision in both the preview and target displays, and we left the frames in their original locations on the screen throughout each trial.

In Experiment 4, the preview display was shown for 200 ms, followed by a 50-ms display of two empty frames (an intervening display), followed by the target display. As in Experiment 3, the duration of the preview display was approximately the mean duration of the preview display in Experiment 1. Once again, the intervening display roughly mimicked the duration of the saccade in Experiment 1. The intervening display also served to alert the subject that the target was present in the plus-flanker same-frame condition, where the preview and target displays were identical. Finally, the presence of the two empty frames in the intervening display ensured that subjects would not perceive motion of the objects from preview to target displays, because the frames were continuously visible in their original locations throughout the trial.

Method

Subjects. Twelve members of the Michigan State University subject pool participated in the experiment for course credit. All subjects had normal or corrected vision. The subjects had not participated in any of the previous experiments and were naive with respect to the hypotheses under investigation.

Stimuli and apparatus. The stimuli and apparatus were identical to those used in Experiment 3, with the exception that the stimuli (preview and targets) were presented centered around fixation (one object above and one below), and an intervening display consisting of the two empty frames was presented between the preview and target displays. These frames were the same as those that surrounded the target letters in the preview and target displays.

Procedure. The procedure was the same as that used in Experiment 3, with the following exceptions: The preview display was shown centrally, and the intervening display contained two frames.

Results

Mean corrected naming latencies collapsed over target position are presented in Table 4. These means exclude trials on which the naming latency was less than 200 ms, more than 1,500 ms, or greater than 3 standard deviations from the mean naming latency for that subject. About 3% of the data were discarded by the naming latency correction. The pattern of corrected latencies did not differ from the pattern prior to correction.

The four within-subject factors of target position, flanker type, continuity, and block were entered into an ANOVA. There were significant main effects of flanker type and block, with naming latencies 48 ms faster in the plus-sign flanker condition (521 ms) than in the letter-flanker condition (569 ms), $F(1, 11) = 74.29$, $p < .001$, $MS_e = 2{,}189$, and 30 ms slower in Block 1 (560 ms) than in Block 2 (530 ms), $F(1, 11) = 8.682$, $p < .05$, $MS_e = 7{,}819$. Flanker type and block interacted, $F(1, 11) = 4.872$, $p < .05$, $MS_e = 936$, with the size of the plus-sign advantage over the letter flanker increasing from 39 ms to 55 ms over the two blocks. There was also a marginal effect of target position, with latencies 10 ms faster when the target appeared in the top (540 ms) rather than the bottom (550 ms) position, $F(1, 11) = 3.221$, $p < .10$, $MS_e = 2{,}327$.

The main effect of continuity was significant, with mean naming latencies of 519 ms, 552 ms, and 564 ms in the same-frame, switch-frame, and control conditions, respectively, $F(2, 22) = 36.80$, $p < .001$, $MS_e = 1{,}400$. Planned comparisons showed that naming latencies in the same-frame condition were faster than in the control condition, $F(1, 11) = 61.46$, $p < .001$, $MS_e = 1{,}557$; latencies in the switch-frame condition were faster than in the control con-

Table 4

Mean Naming Latencies and Mean Preview Benefits (in Milliseconds) as a Function of the Continuity of the Target Relative to the Preview and the Type of Flanker Presented in the Preview: Experiment 4

	Continuity			Preview benefit	
Flanker type	Same	Switch	Control	Object specific	Nonspecific
Letter	562	563	581	1	18
Plus	476	541	546	65	5
M	519	552	564		

dition, $F(1, 11) = 4.479$, $p < .05$, $MS_e = 1{,}441$; and latencies in the same-frame condition were faster than in the switch-frame condition, $F(1, 11) = 43.68$, $p < .001$, $MS_e = 1{,}201$. The effect of continuity was mediated by flanker type, $F(2, 22) = 29.32$, $p < .001$, $MS_e = 957$. Examining the object-specific and nonspecific components of the preview benefit separately (shown in Table 4) revealed that the nonspecific benefit was not influenced by the flanker, $F(1, 11) = 2.232$, $p > .10$, $MS_e = 880$, whereas the object-specific component was, $F(1, 11) = 59.61$, $p < .001$, $MS_e = 840$.

No other effects approached significance, and there was no indication that the preview benefit was reduced across block (all $ps > .10$).

Discussion

In Experiment 4, the perceptual objects were centered around the fixation point so that there was no change to the overall stimulus configuration in either retinal or environmental coordinates from preview to target display. This difference in procedure led to several important differences in the results from the prior three experiments. First, a tendency observed in the first two experiments was exaggerated here: The magnitude of the object-specific preview benefit was smaller when a letter flanker was present than when it was not. In fact, in this experiment, the object-specific benefit was eliminated in the letter-flanker condition (1 ms), whereas it was robust in the plus-flanker condition (65 ms). Again, the conclusion appears to be that the benefit due to the priming of object types is unaffected by an irrelevant flanker in the preview display, whereas the benefit due to the reviewing of object files is affected by an irrelevant flanker; in this experiment, the irrelevant flanker actually eliminated the influence of the object file. Thus, priming appears to be relatively immune to the presence of another relevant object, whereas some aspect of the process of using object files is disrupted by other objects.[3]

General Discussion

The present study was designed to examine dynamic visual identification, and more specifically, the nature of the processes and the types of representations that serve to tie visual objects together over time and space. The four experiments reported here involved the use of a preview paradigm in order to examine how information obtained from an object during one brief view influences identification processes a short time later. The central hypothesis was that preview benefits are produced by a combination of two separate processes, one involving activation of long-term representations of object types (Pollatsek et al., 1990), and the other involving the review of object files (Kahneman et al., 1992).

In Experiments 1 and 2, we examined preview benefits when the preview and target letters appeared during different fixations separated by an intervening eye movement. The results were straightforward. First, the presence of the target in the preview display produced a robust and consistent overall preview benefit. Second, there was evidence for both object-specific and nonspecific preview benefits. Third, the object-specific preview benefit tended to be affected by the presence of an additional, potentially task-relevant object in the preview display, whereas the nonspecific preview benefit was not. In Experiments 3 and 4, we presented the same stimuli to subjects in a within-fixation version of the paradigm, using similar timing parameters as had been used in the eye-movement experiments. In Experiment 3, the retinal events caused by a saccade in Experiment 1 were simulated by presenting the preview stimuli peripherally and the target stimuli centrally. The results were very similar to those observed in the first two experiments, suggesting that the saccade itself plays little role in determining object specificity (see also Pollatsek et al., 1990). In Experiment 4, both the preview and target stimuli were presented centrally so that neither the retinal nor the environmental coordinates of the perceptual objects changed. In this case, virtually no object-specific preview benefit was observed when a potentially task-relevant flanker object appeared in the preview display; a robust object-specific benefit was observed without the flanker.

These results suggest that both temporary object files and long-term object representations can contribute to preview benefits within and across fixations. It appears that a preview of an object can both open an episodic object file (a token) and produce general priming (of the object type). The preview benefit is then produced by a combination of integration within the object file and by priming within a meaning-based or recognition-based network. The priming of established long-term memory representations, as indexed by the nonspecific benefit, is not affected by the presence of a potentially relevant flanker object. This result is consistent with the view that two letters can make contact with long-term representations in parallel (Fisher, 1984). The reviewing of object files, as indexed by the object-specific preview benefit, is affected by the presence of a potentially relevant flanker object. This result suggests that the manipulation of object files is resource limited at some level, so that there is a cost associated with the construction, maintenance, or review of these representations (see also Kahneman et al., 1992). One interpretation of this latter effect is that object files are manipulated in visual short-term memory (Irwin, 1991).

Is it possible that the reviewing of object files could alone account for our entire pattern of data? We consider several ways in which the nonspecific preview benefits that we observed might be accounted for by object files alone. First, object files could produce the preview benefits in the switch-frame condition if the visual system interpreted the change in location from preview to target display as object

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[3] Kahneman et al. (1992) found significant object-specific preview benefits when other task-relevant letters appeared with the target in the preview display. At this point, it is not clear why we do not, though potentially important differences in the paradigms remain. The nature of the boundary conditions surrounding the object-specific benefit is clearly an important open question.

motion (Kahneman et al., 1992). For example, in the Kahneman et al. (1992) study, the location information tied to a given perceptual object was found to move with that object when evidence for motion was provided. However, in the experiments reported here, it is unlikely that subjects perceived the location change as motion. First, subjects do not perceive apparent motion across a saccade, even when the spatial and temporal parameters would otherwise produce good apparent motion (Shioiri & Cavanagh, 1989). Therefore, such an explanation would not account for the results of Experiments 1 and 2 or for the results of the eye-movement experiments reported by Pollatsek et al. (1990). Second, in Experiment 4 the displays were designed so that explicit evidence was provided that the objects were stationary. The frames were visually present in their original locations throughout each trial; only the contents of the frames changed location in the switch-frame condition. Yet, nonspecific preview benefits were observed in this experiment (though they were somewhat smaller). Third, it was our phenomenological impression that the displays in Experiments 3 and 4 did not produce the perception of motion (in fact, the distances we chose were partly based on this observation). However, to further support this impression, we asked eight naive observers to rate the displays of Experiments 3 and 4 for apparent motion.

In this study, the observers were shown several examples of each type of trial, were told the types of questions we would be asking them, and then were shown the trials again. We first asked each observer to describe what the display changes looked like to them. We then asked them to rate their impression of the change on a 5-point scale, with 1 indicating "smooth, continuous motion" and 5 indicating "an abrupt flash." Finally, we asked them the following question: "To the extent that you saw any smooth motion at all, what did it look like?". For Experiment 3, all observers used terms like "flash" and "change" in answer to the open-ended question; no subjects described anything like smooth motion. The modal response on the scale was 3, with all observers giving a 3 or 4. When asked to describe whatever motion was seen, the observers (who found this difficult to answer) indicated that the boxes seemed to move sideways, but that the letters moved diagonally in the switch-location conditions. Thus, to the extent that the observers were describing motion, it was dependent on the identity of the letters. For Experiment 4, all observers again reported that they experienced abrupt offsets and onsets of the letters (remember that the boxes remained in one location throughout each trial in Experiment 4). The modal response for Experiment 4 was 4, and all responses were 4 or 5. Given the noted reluctance of subjects to use the endpoints of a rating scale, we take these data to be conclusive. When asked to describe whatever motion was seen, the observers (after pointing out that they just told us that they had not seen motion) again based their assessments on the identities of the letters.

A second object-file account for the nonspecific preview benefits is that the location of the two perceptual objects was poorly or coarsely coded, so that the two objects were essentially represented as occupying the same location. This explanation seems unlikely to us for two reasons. First, the objects were quite far apart (6° in Experiments 1, 3, and 4; 10° in Experiment 2) and on opposite sides of fixation in Experiment 4. Second, subjects were aware that a letter had changed location during a trial, and the change produced clear effects in all of the experiments, indicating that the location of the target letter was coded.

Finally, we want to consider one other alternative explanation of the data. This interpretation is suggested by the three-way interaction involving target position, flanker type, and continuity observed in Experiment 2. That interaction raises the worry that all of the preview benefits in the four experiments were due to response preparation and not to either object-file review or representation priming. That is, subjects may have simply prepared to name one letter on the basis of the preview (e.g., the sole letter in the plus-flanker condition and the top letter in the letter-flanker condition). Although such an explanation may be a problem in Experiment 2, the interaction among target position, flanker type, and continuity was not observed in any of the other three experiments ($F = 1.35$ in Experiment 1, and Fs < 1 in Experiments 3 and 4), whereas the same general relationship between flanker type and continuity held across target position in each of these experiments. The results of Experiment 1 as a function of target position, flanker type, and continuity (shown in Table 5) illustrate this point. As can be seen, both object-specific and nonspecific benefits were observed regardless of target position. In addition, the fact that naming latencies in the plus-flanker condition were always faster in the same object than the switch-object condition is not consistent with the hypothesis that subjects simply prepared a response to the sole letter present in the preview. Our suspicion is that factors that make it more difficult to encode the letters, such as the increased distance between them in Experiment 2 versus Experiment 1, may lead to the type of selective encoding and response preparation strategy hinted at by the results of Experiment 2. However, this strategy alone cannot explain the entire pattern of effects.

Table 5
Mean Naming Latencies and Mean Preview Benefits (in Milliseconds) as a Function of the Target Position, the Continuity of the Target Relative to the Preview, and the Type of Flanker Presented in the Preview: Experiment 1

	Continuity			Preview benefit	
Flanker type	Same	Switch	Control	Object specific	Nonspecific
			Top position		
Letter	594	630	658	36	28
Plus	519	564	610	45	46
			Bottom position		
Letter	597	617	650	20	33
Plus	516	579	603	63	24

Architectural Implications

The dissociation between object continuity and the presence of a letter flanker suggests that information is maintained over time by two types of representations, object files and object types. However, this finding also raises an issue concerning the purpose of object files. According to the view outlined in the introduction, in addition to allowing token individuation, object files are the episodic representations that are constructed and matched to long-term type representations during identification. Therefore, on this view, all activation at the level of type representations is contingent on the construction of an object file. If the construction of an object file is resource limited, as suggested by the effect of flanker type on the object-specific component of the preview benefit (see also Kahneman et al., 1992), then we would expect to find some effect of flanker type on the activation level in the type representations as well. Although there was a tendency in this direction across experiments, the effects were very small and nonsignificant. The finding that the nonspecific benefit was unaffected by flanker type might be taken to suggest one of two possible architectures. First, it could be that the construction of object files is not an attention-demanding process but that maintaining the files in short-term memory is resource limited. Thus, type activation during the preview would be independent of the number of letters present because construction of the object files would also be independent of that number. Preview benefits due to integration within the object files, however, would be affected by the number of letters in the preview because it would be more difficult to maintain two rather than one object file over time. Second, it could be that object files serve as token individuators along with the related functions outlined by Kahneman et al. (1992), but that they do not make direct contact with long-term memory during identification. According to this "dual-route" hypothesis, a visual stimulus could make direct contact with type representations and could also lead to the construction of an object file, which in turn could contact type representations. Preview benefits due to direct type activation would be independent of the number of letters in the preview, whereas type activation mediated by object files would be affected by number of letters.

Preview Benefits Across Eye Fixations

Saccadic eye movements present the visual system with an interesting problem: Because no useful visual information is acquired during the saccade, the visual system receives discrete glimpses of the world three to four times per second (during the fixations). These glimpses are offset on the retina as a function of the amplitude of the saccade, yet information acquired during one fixation can influence identification during a subsequent fixation. The nature by which preview benefits are produced across saccades has been a long-standing problem in vision. One hypothesis concerning this process that is appealing from a computational perspective is that preview benefits are due to information integration produced by aligning within a spatiotopically organized buffer the information acquired during one fixation with the information acquired during a subsequent fixation (Feldman, 1985; McConkie & Rayner, 1976; Pouget, Fisher, & Sejnowski, 1993; Trehub, 1977). However, a great deal of research has shown that spatiotopic alignment does not occur across saccades (Irwin, Yantis, & Jonides, 1983; Irwin, Zacks, & Brown, 1990; McConkie & Zola, 1979; O'Regan & Levy-Schoen, 1983; Rayner & Pollatsek, 1983; see Irwin, 1991, and Pollatsek & Rayner, 1992, for reviews). Furthermore, the size (Henderson et al., 1987; Pollatsek et al., 1984, 1990), orientation (Pollatsek et al., 1984), and visual details (Pollatsek et al., 1984) of a line drawing of an object can change from one fixation to the next with little or no disruption to identification processes.

To account for the relative insensitivity of the visual system to changes in the visual form of an object from fixation to fixation, it has recently been suggested that very little information is actually carried across the saccade (Irwin, 1991; O'Regan & Levy-Schoen, 1983). The present results suggest that this view may represent a swing of the pendulum too far in the other direction. Instead, both episodic integration within object files and type priming (across many levels of representation) may contribute to preview benefits from one fixation to the next. First, information acquired from an object during one fixation can activate long-term memory representations of that object type. The activation can then prime identification of that object following the saccade. This priming is blind to the spatiotemporal continuity of the object across the saccade because object types do not code this information. Second, information acquired from an object can cause the creation of a temporary object file. Our data provide evidence that integrating the contents of an object file constructed prior to a saccade with information acquired following the saccade can facilitate identification. This integration process is affected by the continuity of the object across the saccade because object files are addressed by spatiotemporal correspondence. We conjecture that the object file active for the object at the location about to be fixated next may help to tie the two fixations together and provide the experience of a seamless visual world by providing the visual system with an active short-term representation common to both the presaccade and postsaccade fixation.

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