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Retinal Masking During Pursuit Eye Movements: Implications for Spatiotopic Visual Persistence

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White (1976) reported that presentation of a masking stimulus during a pursuit eye movement interfered with the perception of a target stimulus that shared the same spatial, rather than retinal, coordinates as the mask. This finding has been interpreted as evidence for the existence of spatiotopic visual persistence. We doubted White's results because they implied a high degree of position constancy during pursuit eye movements, contrary to previous research, and because White did not monitor subjects' eye position during pursuit; if White's subjects did not make continuous pursuit eye movements, it might appear that masking was spatial when in fact it was retinal. We attempted to replicate White's results and found that when eye position was monitored to ensure that subjects made continuous pursuit movements, masking was retinal rather than spatial. Subjects' phenomenal impressions also indicated that retinal, rather than spatial, factors underlay performance in this task. The implications of these and other results regarding the existence of spatiotopic visual persistence are discussed.

Recently several investigators have hypothesized the existence of a spatiotopically defined level of visual persistence that may underlie our perception of a stable visual environment across changes in eye position (e.g., Banks, 1983; Breitmeyer, 1984; Breitmeyer, Kropfl, & Julesz, 1982; Jonides, Irwin, & Yantis, 1982). One seemingly compelling piece of evidence supporting this point of view was provided by White (1976), who reported an interesting set of experiments on visual masking during pursuit eye movements. In one experiment, subjects pursued a dot that moved smoothly across a display screen; at some point, a target stimulus (one of two slanted lines, [/] or [\ ]) appeared on the screen. Subjects were instructed to continue tracking the moving dot, and 100 ms later a metacontrast mask was presented. In one condition, the mask was presented at the same spatial or physical location on the screen where the target stimulus had appeared. In another condition, the mask was presented displaced in space, at the position corresponding to the same retinal location as the stimulus, assuming that the subject continued to pursue the moving dot. White (1976) reported that the mask interfered with target discrimination when it shared the same spatial, rather than retinal, coordinates as the target. This result contrasted with previous research on visual masking during saccadic eye movements, which demonstrated retinal rather than spatial masking (Davidson, Fox, & Dick, 1973). White's results stirred interest for at least two reasons: First, they posed problems for theories of visual masking that rely on retinal contiguity (e.g., Matin, 1975; Weisstein, Ozog, & Szoc, 1975), and second, they suggested that, at least during pursuit eye movements, there exists some spatiotopic representation of the visual world. For reasons detailed below, we doubted White's results; this article reports an attempt (and failure) to replicate White's experiments and a reinterpretation of his findings.

Our attempt to replicate White's experiments was motivated by both theoretical and methodological concerns. On the theoretical side, White's results seemed inconsistent with other work indicating that during pursuit eye movements, position constancy is fairly inaccurate. For example, Hazelhoff and Wiersma (1924) found that when a brief visual stimulus was presented during a pursuit eye movement, perception of its location was erroneously biased in the direction of the tracking movement; the magnitude of this mislocalization was directly proportional to the velocity of the eye movement, as though the retinal image of the stimulus were dragged along for some time prior to stimulus perception. Loss of position constancy during pursuit eye movements has been noted more recently as well (e.g., Mack & Herman, 1978; Mateeff, Yakimoff, & Dimitrov, 1981; Ward, 1976). What is perhaps of most relevance, Stoper (1967) found that when two stimuli were successively presented during a pursuit movement, the two flashes appeared to be aligned when they shared the same retinal, rather than spatial, coordinates. White's results, in contrast, suggest that precise spatial information is maintained during pursuit eye movements.

In addition to these theoretical inconsistencies, there were two major methodological problems with White's experiments. One was that the phosphor used in his graphics display had a very slow rate of decay; its luminance decayed to 10% within 24

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ms after stimulus offset. In the nearly dark viewing conditions White employed, this persistence would be easily visible for even tens of milliseconds longer. The presence of such phosphor persistence is obviously problematical when issues of visual integration or visual masking are concerned (Irwin, Yantis, & Jonides, 1983; Rayner & Pollatsek, 1983). An even more serious problem, however, is that eye position was not monitored during White's experiments. Thus it is not known whether White's subjects actually continued to pursue the tracking dot between the presentation of the test stimulus and the mask. Because presentation of a transient visual stimulus draws attention (Todd & Van Gelder, 1979; Yantis & Jonides, 1985), it is quite possible that White's subjects stopped pursuing the tracking dot when the target stimulus was presented. If this did happen, then in White's "spatial" mask condition the target and the mask would actually share the same *retinal* coordinates, and in his "retinal" mask condition the mask would appear adjacent to the test stimulus and would have little, if any, masking effect. In short, if White's subjects stopped pursuing the tracking dot when the target stimulus was presented, it would appear that masking was spatial when in fact it was retinal.

For these reasons, we attempted to replicate White's experiments under conditions in which phosphor persistence was eliminated and eye movements were monitored to ensure that subjects were actually pursuing the tracking dot. To preview our results, we found that when subjects actually made continuous pursuit eye movements, masking was retinal rather than spatial. This finding has obvious negative import for the argument that there exists a spatiotopic level of visual persistence.

Experiment 1

Method

Subjects. The two authors and a third person, naive as to the hypotheses of the experiment, participated as subjects.

Apparatus. Stimuli were presented on a Hewlett-Packard 1340A display scope equipped with P31 phosphor. A Digital Equipment Corporation Micro-11/23+ computer controlled stimulus presentation via digital-to-analog converters. The computer was also used to record responses typed into the keyboard of a Digital Equipment Corporation VT-240 terminal. Furthermore, it recorded the output from a Gulf+Western Model 210 scleral reflectance eye monitor via analog-to-digital converters. The eye monitor was configured to record from the right eye only, and it was calibrated to be sensitive only to horizontal movements of the eye. The eye monitor was mounted on eyeglass frames that were held snugly in place on subjects' heads via a headband. During the experiment, subjects were seated 72.5 cm from the display scope and used a bitebar with dental impression compound to keep their heads steady. At this viewing distance, the display field subtended 10° of visual angle horizontally, and 7.5° vertically.

Procedure. On every experimental trial, a tracking dot appeared for 1 s at the left side of the display scope and then moved smoothly at a velocity of 0.5 min/ms (approximately 8.3°/s) to the right for 1,200 ms. Subjects were instructed to pursue this tracking dot as it moved across the screen. The target stimulus (/ or \) was presented 400–800 ms after the tracking dot began to move; thus, it appeared at a randomly determined screen location from trial to trial, but always in the central third of the display screen. The target stimulus was 10.5 min high, and its top was horizontally displaced from its base by 2 min; thus, the angle of tilt was 10.8°. The target stimulus was presented 22.5 min directly above the tracking dot, for a duration of approximately 0.1 ms. One of three events occurred 60 ms after target presentation: (a) A noise mask composed of a grid of dots 30 min wide and 10.5 min high was presented for 1 ms, centered at the same physical (i.e., spatial) location where the target stimulus had been presented; (b) the noise mask was presented centered 30 min to the right of the presentation location of the target stimulus, at the point corresponding to the retinal location of the target, assuming that the subject continued to pursue the tracking dot; or (c) no mask was presented. These three types of mask events occurred randomly from trial to trial. When the subject finished pursuing the tracking dot to the right edge of the screen, he typed one of two keys (/ or \) to indicate which stimulus he thought had been presented.

Eye position was monitored (for 1,200 ms, at a rate of once per millisecond) throughout each experimental trial, and several criteria had to be met in order for the trial to be accepted. These criteria concerned eye movement velocity during the 60 ms intervening between target presentation and mask presentation, and the 100 ms before and after this interval. If the eyes stopped (defined as an eye velocity of 1°/s or less for any 10-ms interval) anytime during this period, the trial was rejected; if a saccade (defined as an eye velocity of greater than 16.7°/s for any 10-ms interval) occurred anytime during this period, the trial was rejected; and finally, if the overall velocity of the movement was too slow (defined as a velocity less than 6.7°/s) during the critical period, the trial was rejected. Subjects received feedback after each trial about their eye movement. Rejected trials were repeated later in the block of trials. After several blocks of practice, each subject completed 10 blocks of 30 acceptable trials each; of these 30 trials, 10 were of each masking type (spatial, retinal, or none), and of these 10, half employed (/) as the target and half employed (\). Subject 1 (DEI) required 516 trials to complete 300 acceptable trials; Subject 2 (J-SS) required 373 trials; and Subject 3 (naive) required 387.

Persistence test. In order to reduce phosphor persistence visibility, the target stimuli were presented at a low level of illumination for a very brief duration, and the overhead lights in the experimental room were left on during the experiment. To ensure that these measures were effective, Subjects 1 and 3 completed the following psychophysical test before any experiments were conducted. A closed tachistoscopic shutter was placed in front of the display scope. One of the two target stimuli—(/) or (\)—was then presented on the scope for the same duration as used in the experiment, but at a somewhat higher illumination. Approximately 2 ms after stimulus presentation was terminated, the shutter opened. The subjects' task was to say which target stimulus had been presented. Subject 1 was correct on 25 of 50 trials, and Subject 3 was correct on 28 of 50. Neither of these scores is above chance. Furthermore, neither subject was able to see any trace of phosphor persistence on the screen when the shutter opened. Given these results, plus the fact that the target illumination actually used in the experiments was lower than that used in this test, it's probably safe to conclude that phosphor persistence did not contribute in any way to the obtained experimental results.

Results and Discussion

The percentage of correct tilt discrimination responses was calculated for each mask type (spatial, retinal, and none) for each subject. The results are shown in Table 1. A separate analysis of variance was calculated for each subject, with factors of mask type (fixed, 3 levels) and block (random, 10 levels). These analyses showed that for each subject, there was no significant difference in accuracy between the no-mask and spatial mask trials, but accuracy on both no-mask and spatial mask trials was significantly higher than was accuracy for the retinal mask trials (Bonferroni 95% confidence interval halfwidths for the

Table 1
Percentage of Correct Responses for Retinal, Spatial, and No-Mask Trials in Experiment 1

Subject	Retinal mask	Spatial mask	No mask
DEI	75	84	89
J-SS	59	82	91
Naive	82	92	95
Average	72	86	92

difference between two means were 7.8%, 12.8%, and 9.7% for the 3 subjects).

In summary, the results of Experiment 1 showed that masking during pursuit eye movements is retinal, rather than spatial. These results contradict those of White (1976). It appears that when phosphor persistence is eliminated and eye movements are monitored to ensure that subjects actually pursue the tracking dot, retinal masking occurs. The importance of monitoring eye movements is amply demonstrated by the fact that even after extensive practice, we had to repeat a significant number of trials because of various eye movement artifacts. The sudden presentation of the target stimulus makes it difficult for subjects to continue pursuing the tracking dot. If pursuit stops between target presentation and mask presentation, it will appear that masking is spatial when in fact it is retinal. This is the likely cause of White's results.

It should be pointed out however, that there were several procedural differences between our study and White's. In White's first two experiments, an interstimulus interval (ISI) of 100 ms separated target and mask, whereas in our experiment an ISI of 60 ms was used. We used a 60-ms ISI because in pilot testing, our subjects' performance was at ceiling with a 100-ms ISI. This difference in procedure is probably not critical, because in White's Experiment 3 he used ISIs of 50, 100, and 150 ms and found spatial masking for both 50 and 100 ms. Another, potentially more critical difference between our procedures, however, regards the type of mask that was employed. White employed a metacontrast mask, whereas we used a noise mask. Given the different masking functions sometimes found with these different kinds of masks (Kahneman, 1968), it is conceivable that if we had employed a metacontrast mask we might have obtained White's results. This possibility was examined in Experiment 2.

Experiment 2

Method

Subjects. The same 3 subjects used in Experiment 1 were used in this experiment.

Apparatus. The same apparatus used in Experiment 1 was used in this experiment.

Procedure. The experimental procedure was identical to that of Experiment 1 with three exceptions. First, a metacontrast mask in the shape of a rectangle 10 min wide and 16.5 min high was used instead of a noise mask. Second, the ISI between target presentation and mask presentation was reduced to 50 ms. Third, the mask was presented at a much higher intensity than the target, because preliminary testing showed this was necessary to produce a masking effect. As in Experiment 1, what kind of mask was presented (spatial, retinal, or none) was varied randomly from trial to trial. On spatial mask trials, the mask was presented at the same physical location where the target had appeared, and in the retinal mask condition it was presented 25 min to the right of the target presentation point.

Subjects were instructed to continuously pursue the tracking dot as it moved smoothly across the screen at a velocity of 0.5 min/ms; eye position was monitored throughout each trial. The same criteria for successful pursuit that were used in Experiment 1 were also used in this experiment, and subjects again received feedback after each trial about their eye movement. Each subject completed 10 blocks of 30 acceptable trials each, with each block counterbalanced for mask type and target type. Subject 1 (DEI) required 444 trials to complete 300 acceptable trials; Subject 2 (J-SS) required 459 trials; and Subject 3 (naive) required 367.

Results and Discussion

The percentage of correct tilt discrimination responses was calculated for each mask type (spatial, retinal, and none) for each subject. The results are shown in Table 2. A separate analysis of variance was calculated for each subject, with factors of mask type (fixed, 3 levels) and block (random, 10 levels). These analyses showed that for all 3 subjects accuracy on retinal mask trials was significantly lower than accuracy on spatial mask and no-mask trials. These results replicate those of Experiment 1. However, unlike Experiment 1, in this study accuracy on spatial mask trials was significantly lower than accuracy on no-mask trials for 2 of the 3 subjects (Bonferroni 95% confidence interval halfwidths for the difference between two means were 7.9%, 10.4%, and 9.4% for the 3 subjects). The drop in accuracy under spatial masking conditions might actually be a retinal, rather than a spatial, phenomenon, however, caused by lateral masking from the close retinal proximity of the spatial mask to the target stimulus; under the exposure conditions used in this experiment, the target and the spatial mask were separated on the retina by less than 25 min of arc, easily in the range of inhibitory lateral masking effects. In order to test this hypothesis, the 3 subjects each completed an additional 100 trials in which they maintained fixation at a central point at which target stimuli were presented, followed after 50 ms by the presentation of the metacontrast mask either at the same location as the target stimulus or centered 25 min away. This configuration thus mimicked the retinal layout of the retinal mask and spatial mask conditions of Experiment 2, but without eye movements. The results of this control study are shown in Table 3. With eyes stationary, when the target and the mask shared the same retinal coordinates, accuracy for the 3 subjects was very similar to that of the retinal mask condition of Experiment 2; when the mask was presented adjacent to the target stimulus, thus simulating the retinal layout of the spatial mask condition in Experiment 2, subjects' accuracy was almost identical to their accuracy in the spatial mask condition of Experiment 2. This control study thus provides support for the claim that the significant drop in accuracy for spatial mask trials in Experiment 2 is actually a consequence of retinal, rather than spatial, factors.

In any event, the most important finding of the second experiment was that a large retinal masking effect was found even when a metacontrast mask was used. The results of the first two

Table 2
Percentage of Correct Responses for Retinal, Spatial, and No-Mask Trials in Experiment 2

Subject	Retinal mask	Spatial mask	No mask
DEI	78	95	98
J-SS	56	68	86
Naive	62	86	96
Average	65	83	93

experiments thus contradict those of White, who found masking to be spatial rather than retinal. As we discussed after Experiment 1, it seems likely that White's results were due to subjects' failing to continue pursuing the tracking dot between target and mask presentation. This was a fairly common error in our experiments, as shown by the large number of trials we rejected because of inappropriate eye movements.

Subjects' introspections also indicated that retinal, rather than spatial, factors controlled performance in the first two experiments. On retinal mask trials in which acceptable eye movements were made, subjects reported "seeing" overlap or fusion of the target stimulus and the mask; on acceptable spatial mask trials, however, subjects reported "seeing" the target to the right of the mask, corresponding to the actual retinal configuration of this condition. These introspective data agree with those of Hazelhoff and Wiersma (1924) and Stoper (1967) described earlier. In fact, White (1976) also noted a similar retinal displacement effect; using the method of constant stimuli to measure its magnitude, he found that the first of two lines presented 100 ms apart during a 8.3°/s (i.e., 0.5 min/ms) pursuit movement appeared to be displaced 10 min in the direction of the pursuit movement. This amount of displacement is surprisingly small compared with previous estimates; considering Stoper's (1967) finding that two stimuli successively presented during a pursuit movement appear to be aligned when they share the same retinal coordinates, White should have obtained a retinal displacement effect of 50 min, rather than 10. The small displacement effect obtained by White is consistent with the argument that his subjects were not continuously pursuing the tracking dot between target and mask presentation; rather, they must have stopped or slowed down when the target stimulus was presented. Under these circumstances, both a small retinal displacement effect and "spatial" (actually, retinal) masking would occur. In Experiment 3 we addressed this issue empirically, by using the method of Stoper (1967) and White (1976) to measure the magnitude of retinal displacement experienced by our subjects during pursuit movements.

Experiment 3

Method

Subjects. The same subjects used in Experiments 1 and 2 participated in this experiment.

Apparatus. The same apparatus used in the first two experiments was used in this experiment.

Procedure. The method of constant stimuli was used to measure the amount of apparent retinal displacement of a stimulus presented during a pursuit eye movement. On each trial, a tracking dot appeared for 1 s at the left side of the oscilloscope and then moved smoothly at a velocity of 0.5 min/ms (8.3°/s) to the right. Subjects were instructed to pursue this dot as it moved across the screen, and their eye movements were monitored to ensure accurate pursuit. Four hundred to 800 ms after the tracking dot began to move, a vertical line 10.5 min high was presented for 0.1 ms 22.5 min above the tracking dot. Subjects continued to pursue the tracking dot, and either 50 or 100 ms later a second vertical line 10.5 min high was presented for 0.1 ms 22.5 min below the path of the tracking dot. When the ISI was 50 ms, this second stimulus was presented at one of six displacements to the right of the first stimulus: 0, 10, 20, 30, 40, or 50 min of arc. When the ISI was 100 ms, the second stimulus was presented either 20, 30, 40, 50, 60, or 70 min of arc to the right of the first stimulus (these values were determined on the basis of preliminary testing with this procedure). Interstimulus interval and displacement magnitude varied randomly from trial to trial. The subjects' task was to say whether the second stimulus appeared to be to the right, left, or in the same position as the first stimulus.

Subjects' pursuit eye movements had to meet the criteria described in Experiment 1 in order for a trial to be acceptable; subjects received feedback after each trial about their eye movement. Each subject completed 5 blocks of 60 acceptable trials each; of these 60, 30 employed an ISI of 50 ms and 30 employed an ISI of 100 ms. Of each 30 trials, 5 occurred at each of the six possible displacements. Trials in which eye movement artifacts occurred were repeated later in the block of trials. Subject 1 (DEI) required 438 trials to complete 300 acceptable trials; Subject 2 (J-SS) required 477; and Subject 3 (naive) required 424.

Results and Discussion

The proportion of trials in which the second stimulus appeared to be to the right of the first stimulus was calculated for each displacement at each ISI for each subject. A trial in which the subject reported the two stimuli as appearing at the same position was counted as half-left and half-right (Engen, 1971). The point of subjective equality for the two stimuli at each ISI was then calculated by least squares regression for each subject. These values are shown in Table 4. If subjects were closely pursuing the tracking dot at its velocity of 0.5 min/ms, a retinal displacement of 25 min should be found at a 50-ms ISI, and a displacement of 50 min should be found at a 100-ms ISI. We found displacements of 22.6 and 46.0 min at these two ISIs when we averaged the estimate of retinal displacement for each subject. These results are in substantial agreement with Stoper (1967), who also monitored subjects' eye position during pursuit, but contradict those of White, who did not monitor eye position and found a retinal displacement effect of only 10 min at a 100-ms ISI. White's subjects must not have made continu-

Table 3
Percentage of Correct Responses for Retinal and Adjacent Mask Trials in Control Study of Experiment 2

Subject	Retinal mask	Adjacent mask
DEI	60	98
J-SS	54	62
Naive	50	82
Average	55	81

Table 4
Apparent Retinal Displacement (in min of arc) for Stimulus Presented During 8.3°/s Pursuit Eye Movement

Subject	50-ms ISI	100-ms ISI
	25.0	50.0
DEI	24.0	49.6
J-SS	20.8	43.2
Naive	23.1	45.2
Average	22.6	46.0

Note. ISI = interstimulus interval.

ous pursuit eye movements between the presentation of successive stimuli.

General Discussion

The experiments reported above show that masking during pursuit eye movements is retinal, rather than spatial. That is, presentation of a masking stimulus during a pursuit eye movement interferes with the perception of a stimulus that shares the same retinal, rather than spatial, coordinates as the mask. This result contradicts those of White (1976). White most probably obtained his results because it is very difficult for subjects to continue pursuing a tracking dot when a transient visual target is presented. This was certainly the case in our experiments; we had to repeat approximately 40% of the trials we ran because of eye movement artifacts. Because White did not monitor eye position, trials in which subjects failed to pursue accurately would contaminate his results. In particular, if White's subjects stopped pursuing the tracking dot when the target stimulus was presented, target and mask would actually share the same retinal coordinates in his "spatial" mask condition and would occupy adjacent regions of the retina in his "retinal" mask condition. Thus, masking would appear to be spatial when in fact it was retinal. This reinterpretation of White's results is supported by his own finding that the target stimulus appeared to be displaced by only 10 min of arc in the direction of the pursuit eye movement, rather than the 50 min expected from Stoper's (1967) work and from our third experiment. Also worthy of mention is the fact that White actually found his largest masking effect in a third condition of his experiments, in which the mask was presented at the "apparent" location of the stimulus, rather than at its "retinal" or "spatial" positions (although masking was not significantly different at this point than in the spatial condition; of course, because these two positions were separated on the retina by only 10 min of arc, it's not surprising they weren't very different). Because our third experiment indicates that the "apparent" location of the target stimulus corresponds to its retinal location, White's results are totally consistent with retinal masking; it was only his failure to monitor eye position that led him to conclude that masking was spatial rather than retinal.

Our finding that masking during pursuit eye movements is retinal, rather than spatial, is consistent with other work described earlier indicating that position constancy is fairly inaccurate during pursuit eye movements (e.g., Hazelhoff & Wiersma, 1924; Mack & Herman, 1978; Mateeff et al., 1981; Ward, 1976; but cf. Hansen, 1979, who found that *motor* localization during pursuit is quite accurate). It is also consistent with various retinotopic theories of visual masking and with previous research indicating that during saccadic eye movements visual masking is retinal rather than spatial (Davidson et al., 1973). The problems posed by White's original results for each of these areas of research vanish under our reinterpretation of his findings.

Finally, our demonstration that White's results were due to retinal rather than spatial factors weakens the argument in favor of the existence of a spatiotopic level of visual persistence. In fact, although such a level of persistence has intuitive appeal, there is little compelling evidence for its existence. Some evidence is directly negative; for example, McConkie, Rayner, and colleagues have shown that changing letter case or, under some conditions, even letter identities during an eye movement has no disruptive effect on reading or word naming (e.g., McConkie & Zola, 1979; McConkie, Zola, Blanchard, & Wolverton, 1982; Rayner, McConkie, & Zola, 1980). In addition, Pollatsek, Rayner, and Collins (1984) have found similar noneffects when pictures are used as stimuli. If there were spatiotopic visual persistence, one might expect it would interfere with performance under these conditions. Other findings inconsistent with the existence of spatiotopic visual persistence have been provided by several investigators' demonstration that different visual patterns viewed in successive fixations cannot be fused in memory according to their spatial coordinates in order to produce an integrated composite pattern (e.g., Bridgeman & Mayer, 1983; Irwin, Yantis, & Jonides, 1983; Jonides, Irwin, & Yantis, 1983; O'Regan & Levy-Schoen, 1983; Rayner & Pollatsek, 1983). One might expect such integration to be possible if there were spatiotopic visual persistence.

In addition to this negative evidence, other studies that have been cited in support of the existence of spatiotopic visual persistence are somewhat ambiguous. For example, Ritter (1976) reported that two light flashes presented at the same spatial location, but separated by a saccade so that they stimulated different retinal locations, were perceived as one flash if the interflash interval was less than about 75 ms. This result could be due to spatiotopic visual persistence of the first flash, but it can also be explained in terms of saccadic suppression. Wolf, Hauske, and Lupp (1978, 1980) found that the detection threshold for a spatial frequency grating decreased if an identical spatial frequency "priming" stimulus was presented at the same location just prior to a saccade. This result could be due to spatiotopic visual persistence of the priming stimulus, but it could also be due to phosphor persistence on the display scope used by Wolf et al. (cf., Irwin et al., 1983; Jonides et al., 1982; Jonides et al., 1983; Rayner & Pollatsek, 1983). Perhaps the best evidence in support of spatiotopic visual persistence has been provided by Davidson et al. (1973); they presented a letter array in one fixation and a mask at one of the letter positions in a second fixation, and found that the mask inhibited report of the letter that shared its retinal coordinates but *appeared* to occupy the same position as the letter that shared its spatial coordinates. This latter phenomenon is quite suggestive, but it's important to note that Davidson et al. reported that the two flashes of information presented before and after the saccade never appeared to be simultaneously present; thus, whether subjects' introspective reports in this task were due to spatiotopic visual persistence is unclear.

In conclusion, the concept of spatiotopic visual persistence is interesting and intuitively appealing, but there is no clear evidence for its existence. The experiments reported in the present article have further weakened what evidence there was for spatiotopic persistence by showing that, contrary to previous claims, masking during pursuit eye movements is retinal rather than spatial.

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