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Induced Motion and Oculomotor Capture

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Three experiments investigating the basis of induced motion are reported. The proposition that induced motion is based on the visual capture of eye-position information and is therefore a subject-relative, rather than object-relative, motion was explored in the first experiment. Observers made saccades to an invisible auditory stimulus following fixation on a stationary stimulus in which motion was induced. In the remaining two experiments, the question of whether perceived induced motion produces a straight ahead shift was explored. The critical eye movement was directed to apparent straight ahead. Because these saccades partially compensated for the apparent displacement of the induction stimulus, and saccades to the auditory stimulus did not, we conclude that induced motion is not based on oculomotor visual capture. Rather, it is accompanied by a shift in the judged direction of straight ahead, an instance of the *straight ahead shift*. The results support an object-relative theory of induced motion.

Induced motion (IM) occurs when the motion of one object, usually a surround, causes a stationary object to appear to move in the opposite direction, or when the motion of a surrounding object affects the apparent direction or velocity of an enclosed moving object. In describing his extensive investigations of this phenomenon, Duncker (1929) distinguished between two principal reference systems in which any motion can occur: a subject-relative, or egocentric, system and an object-relative, or exocentric, system. Induced motion was his prime example of an object-relative motion. According to Duncker, induced object motion is based on the distance change between two visual objects, one of which serves as the frame of reference for the other. In the simplest case in which a moving surround causes an enclosed stationary point to appear to move in the opposite direction, the surround provides the frame of reference for the point's motion. "If of two objects, one is more localized relative to the other than the other to it, it tends, through a distance change between the two—to the extent that the subject-relative movement values may be ignored—more towards phenomenal movement than the other" (Duncker, 1929, p. 204[1]). In other words, IM of the point is perceived to the extent that its position in relation to the self, which is, of course, invariant, is ignored.

Information about the subject-relative position of any object, its position relative to the head, is provided by the retinal position of its image and information about the position of the eyes in the head. In the case of IM when the motion of the surround is above the absolute (subject-relative) threshold for motion detection, this information signals that the enclosed object is stationary and the surround is moving. For example, if the stationary object is fixated, the information that the eyes and the image of the fixated object are stationary signifies that this object is stationary with respect to the head, whereas the retinal displacement of the image of the surround signals that it is moving in relation to the head. Conversely, if the moving surround is tracked, its motion relative to the head is signaled by pursuit, and the stability of the enclosed point is signaled by the retinal displacement of its image. In contrast, information about the object-relative position of any object (e.g., the enclosed point) is based

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[1] All page references to Duncker (1929) refer to the original article. Translations from the German have been rendered by F. Heuer.

on its position relative to another visual object, in this case the surround. The fact that IM may be perceived when the inducing motion is above the subject-relative threshold attests to the importance of object-relative reference systems for perception (Mack, 1978).

The force of Duncker's claim that IM is strictly an object-relative motion is most clearly revealed by his treatment of what he referred to as an apparent distance paradox. This paradox arises when the motion of the surround is above threshold and both the motion of the surround and an IM of the enclosed point are perceived simultaneously. When this occurs, "the sum of the opposed phenomenal movement excursions of the induced and inducing objects is greater than the phenomenal distance change between them, and, under certain circumstances, almost twice as great" (Duncker, 1929, p. 196). Duncker resolved this paradox with the concept of *separation of systems.* The IM, based on the distance change between the objects is only an object-relative motion. The perceived motion of the surround is a subject-relative motion based on its position change in relation to the head. Because these motions occur within different reference systems, there is nothing paradoxical about perceiving them simultaneously.

Several investigators have offered a different analysis of IM, claiming that it is a subject-, not object-, relative motion. These investigators either implicitly or explicitly proposed that IM entails the visual capture of conflicting subject-relative position information. Brosgole (1968) argued that IM is caused by a shift in the observer's apparent straight ahead, produced by the displacement of the surround which, on Brosgole's account, determines subjective straight ahead. He construed IM as a dynamic version of the Roelofs' (1935) effect (i.e., the displacement of the apparent median plane which may occur when a rectangular luminous contour is placed asymmetrically with respect to it). Implicit in this argument is the assumption that the shift in straight ahead is based on the visual capture of head- or body-position information. This assumption, however, is neither directly supported by any evidence nor consistent with the phenomenal experience of IM. Rather, the experience of feeling one's head or body move is intimately associated with the phenomenon of induced motion of the self.

Recently, two independent groups of investigators proposed a more sophisticated account of the subject-relative theory of IM which explicitly posits the visual capture of eye-position information. Rock, Auster, Schiffman, and Wheeler (1980) argued that IM is motion subtracted from the motion of the surround. In contradiction to Duncker, Rock et al. presented evidence that, at least with above-threshold slow motions of the surround, IM tends to be perceived only to the extent that the frame's motion is not. Following Duncker, Rock et al. attributed IM to the relative displacement between an enclosed stimulus and a surround. For Duncker the surround serves as the frame of reference for the enclosed stimulus so that when the surround motion is below threshold, the relative displacement is attributed to the enclosed object, revealing what appears to be a principle of perceptual organization. This principle is accepted by Rock and his associates, who consider the surround a "world surrogate." However, unlike Duncker, they rejected the concept of separation of systems and instead argued that the displacement of the surround is either assigned wholly to the enclosed stimulus or apportioned between it and the surround so that the perception of motion in the array does not exceed the motion in the retinal stimulus. (As the investigators themselves recognized, this account does not explain why IM can be generated stroboscopically where the inducing motion is extremely fast.) This argument leads directly to the assumption that the perception of IM is inextricably linked to the visual capture of oculomotor information. The motion of the surround is subject relative. The IM is motion subtracted from it; therefore, it too is subject relative. For this to be so, there must be (and according to this view there is) visual capture of eye-position information. That is, if the observer is actually fixating a stationary stimulus in which motion is induced, a pursuit eye movement, consistent with the IM, is registered. The conjunction of this misregistered eye-position information and the fact that the image of the fixated stimulus does not displace signifies object motion with respect to the head. Further, the retinal displacement of the surround, actually a consequence of its real motion, is now attributed to the registered pursuit movement.

Thus, according to Rock and his collaborators, IM entails visual capture. What is not clear, however, is whether in this view the capture of eye-position information is caused by or causes the IM. A slightly different version of this argument presented by McConkie and Farber (1979) is clearer on this point: "Attributing the retinal drift of the surround to eye movement could account for the apparent (induced) motion of the center in classical induced motion displays" (p. 507). Here it seems quite clear that the IM is assumed to be based on or caused by the visual capture of eye position. Unlike Brosgole's assumption of visual capture, this assumption does have a certain face validity, although it is not supported by any direct evidence. Observers do frequently experience that their eyes, in fact, are moving when they perceive IM even though their eyes actually remain fixated on the physically stationary stimulus (Mack, Fendrich, & Wong, 1982).

The argument that a visual array which induces motion produces visual capture of eye-position information may be considered a version of Gibson's (1968) view that there is "sensationless proprioception" or "visual kinesthesis." Gibson radically dismissed the idea that extraretinal eye-position information plays a disambiguating role in the perception of motion and position. Instead, he argued that information about eye position is directly given by the ambient optic array. "The animal does not have to 'feel' to 'know' where his eye is pointing for he can, as it were, 'see' where it is pointing" (Gibson, 1968, p. 342). Because the retinal displacement of the entire surround is normally associated with motions of the eye, the displacement of the inducing surround is simply misread as the consequence of an eye movement and the relative displacement between it and the induction stimulus, the ecologically invariant feature of object motion, signifies that the eye and fixated object are moving. Because Gibson dismissed the role of extraretinal eye-position information in perception, he would not consider this an instance of visual capture but rather the ecologically valid reading of the visual input. Thus, on this analysis as well, IM is subject relative.

We hope to address the question of whether IM is object- or subject-relative motion, entailing visual capture of oculomotor information, or in Gibson's terms the misreading of the visual stimulation by looking at whether or not we orient accurately with an unseen limb to a stimulus that undergoes an IM. Because the principal source of veridical, subject-relative position information lies in the relation between the retinal indexes of image-position and eye-position information, if eye-position information were captured by the perception of IM, there would be no independent source of subject-relative position information which could serve to guide the orienting response accurately. Consequently, the orienting response must reflect the IM. For example, if the eye were registered as moving when in fact it was fixating the stationary stimulus in which motion was induced, the sensory-motor system responsible for guiding the limb to the target would have access to no information discrepant with this perception. Consequently, the orienting response would necessarily conform to the perception.

Unfortunately, the relevant evidence is ambiguous. The positioning of both the hand or arm and the eye to a stimulus that undergoes IM has been investigated. The investigations of whether we point to the apparent or actual position of an induction stimulus, all of which involved open-loop responses, have produced evidence compatible with all the possible answers to this question. Farber (1979) reported that perceived IM is manually tracked. Bacon, Gordon, and Schulman (1982) reported that pointing only partially reflects the induction when the observers are required to point to the terminal location of a target that has undergone IM, and this replicates a finding previously reported (Sugarman & Cohen, 1968). In contradiction to these results, Bridgeman, Kirch, and Sperling (1981) reported that observers point accurately to a target that appears to step because of a step displacement of a surround, but they point somewhat less accurately to a target that appears to move because of the sinusoidal motion of a surround. Because of the conflicting character of these findings, no clear conclusion about the relation between the perception of IM and pointing is possible.

Investigations of the influence of perceived

IM on eye position clearly indicate that the eye neither tracks the IM of a visible stimulus (Mack et al., 1982) nor saccades to the apparent position of a stimulus that undergoes an induced, discrete step displacement (Wong & Mack, 1981). However, although these results demonstrate that eye movements to a stimulus in which motion is induced are not governed by perception, they do not bear on the question of whether IM is based on the visual capture of eye position. Because the eye movements in these studies were always responses to visible stimuli, they could be programmed in terms of retinal position, (i.e., offset from the fovea) even if eye position were misregistered. Inferences about the presence or absence of visual capture are only legitimate if the position to which the eye must go is not visually marked so that this retinal-position information is eliminated. In this case, if visual capture of eye-position information occurs, then, when an observer saccades to a visually unmarked position following accurate fixation of a stimulus in which motion has been induced, the saccade can only be programmed in terms of misregistered eye-position information. Consequently, the saccade will be based on the position of the target relative to the perceived position of the induction stimulus, rather than on the actual position of the eye.

To our knowledge, there is only one report of an experiment involving a condition in which observers were required to move their eyes to a visually unmarked target following fixation of a stimulus in which motion was induced (Wong & Mack, 1981). This condition was part of a group of experiments designed to determine whether, and under what conditions, saccades are directed to a target's perceived location, and it yielded results that are consistent with the visual capture hypothesis. Observers were shown either an induced motion or induced step displacement. The visual display was then eliminated, which was the signal for the observer to look back to the remembered, starting position of the stimulus which had undergone the IM. With both the induced motion and the induced step displacement, the "look-back" saccade brought the eye to the position the target would have initially occupied if it had moved or stepped as it had appeared to. This is precisely the outcome expected if IM causes visual capture of eye-position information.

However, because this outcome is amenable to two other plausible explanations, it is not possible to infer visual capture from these results. First, because subjects perceived an IM or displacement of the point which they were required to fixate, they also believed that their eyes had moved to conform with the perceived motion or displacement. Consequently, they may have felt obliged to execute a look-back saccade which was consistent with this belief, even in the absence of any visual capture of the oculomotor information. That is, the demand characteristics of the procedure, which included the instruction to look back to the starting position of the induction object's trajectory, might have prompted the subject to make an eye movement consistent with the perceived induction even though this conflicted with veridical eye-position information. If so, this would not be evidence of oculomotor visual capture. (A somewhat similar point has been made by Bridgeman et al., 1981, in relation to procedures involving pointing to a target that undergoes an IM.)

Second, even if these results had been completely unaffected by experimental demand characteristics, they would still not be unequivocal evidence of visual capture, because they might have been produced by what Harris (1974) called a "Straight Ahead Shift." Harris described a straight ahead shift as a change in judged straight ahead which masquerades as an alteration of perceived position. Its single most diagnostic symptom is that only tasks involving the straight ahead are affected, whereas all other tasks that should be similarly affected if a truly perceptual shift has occurred are unchanged. Although Harris discussed this phenomenon primarily in the context of perceptual adaptation, he recognized that it might have wider application. Even though all the eliciting conditions for a straight ahead shift have not been systematically documented, the effect may be suspected whenever stimulus conditions that might affect the judgment of straight ahead are present and whenever testing procedures require observers to locate the straight ahead. Unfortunately, both these conditions may have been present in Wong and Mack's experiment, and one of them surely was. The critical measure that provided the possible basis for an inference concerning the presence or absence of oculomotor capture required observers to look back to a target that was always initially placed straight ahead. Thus, the dependent measure was one that would have been affected by a straight ahead shift if one had occurred. The possible influence of the stimulus conditions on straight ahead judgments is less clear, although we do know that under conditions that appear quite comparable with those involved in this experiment, a rectangular contour placed asymmetrically with respect to straight ahead can displace it toward the center of the rectangle (Roelofs, 1935). In fact, as noted previously, the existence of the Roelofs effect provided the basis for Brosgole's proposed explanation of IM.

The experiments we report here were designed to determine whether either oculomotor visual capture or a straight ahead shift occur when IM is perceived. The first experiment seeks to determine whether visual capture occurs under testing conditions that eliminate the possibility that the obtained results can be a function of a straight ahead shift. The second and third experiments focus on the question of a straight ahead shift. In all the experiments, every effort was made to reduce severely the likelihood that the critical eye movements would be affected by the observer's wish to be self-consistent.

In Experiment 1 observers were required to look to the position of an invisible auditory stimulus after fixation on a visible stimulus in which motion was induced. If visual capture occurs, these saccades should reveal it, because the position of the eye when these saccades are initiated will be misregistered. Thus, if a stationary, fixated induction stimulus, which is only slightly to the right of the auditory target, appears to move 9° to the right, the saccade to this auditory target should move the eye 9° too far to the left if capture is complete.

Experiment 1

Method

Subjects. Twenty subjects recruited from the New School community were paid for their participation. Ten served in the first condition, and 10 served in the second condition. All observers were unfamiliar with the phenomenon of IM.

Apparatus. The visual display was presented on a fast phosphor (P15) CRT. Eye movements were monitored by a Biometric infrared reflecting, goggle system (Biometric Eye Trac, Model 200). This system is accurate within approximately ±1° and is essentially silent. It was used to monitor horizontal eye movements only. It was not possible to monitor eye movements with the far more precise Double Purkinje Image Eye Tracker used in Experiments 2A, 2B, and 3, because the noise it made when tracking the eye obscured the auditory stimulus and made auditory localization virtually impossible. The output of the eye-movement monitoring system was recorded on a multichannel polygraph. The auditory signal was generated by a Commodore 64 microcomputer, which was wired through a small amplifier and circuit switch to two mini-earphone speakers positioned immediately in front of the oscilloscope display screen. The auditory signal consisted of a 2-s, 5-Hz square wave, the loudness of which was adjusted so that it was clearly audible. The upper and lower sections of the display screen were covered with black felt so that only a horizontal band within which the visual display appeared was uncovered. This eliminated any visual cue to the positions of the speakers which might have come from screen light when the visual display was present.

Display. The display consisted of a 12° × 4° luminous rectangular contour initially centered around the observer's straight ahead. It surrounded a luminous point which, at the outset of the motion trials, was placed 1.5° inward of its left edge. The two speakers which served as auditory targets were placed slightly below the lower edge of the rectangle. One speaker was aligned with the rectangle's right edge and the other with its left; consequently, the speakers were separated by 12°. (See Figure 1). Both the frame and point could be moved. For purposes discussed next, another point could be displayed on the screen at the same level as the enclosed fixation point. This point could be positioned by the experimenter within a 20°-range, which extended from 4° to the right of the frame to 4° to its left.

Procedure. Prior to testing, the eye-tracking system was calibrated and observers' ability to localize and saccade to an auditory stimulus was assessed. During this procedure, the sound sources were never visible and the observers received no feedback. Eight potential subjects were eliminated from the experiment during pretesting: five were unable to saccade to an auditory target, their saccades being essentially random[2], and 3 were unable to discriminate between the left and right auditory signals.

Motion conditions. There were two kinds of motion trials: One involved frame motion (induction trials) and the other involved point motion. Both kinds of trials began with the frame centered about straight ahead and

[2] The fact that 5 of 25 subjects could not perform the saccadic task even though they had no difficulty localizing the sound when that entailed positioning a point may be relevant to our understanding of the oculomotor control system. This finding was surprising given the report (Zahn, Abel, & Dell'Osso, 1978) that observers are as accurate in saccading to auditory as to visual targets.

the point located 1.5° from its left edge (see Figure 1). On frame motion trials, the point remained stationary while the frame moved 9° leftward, inducing a rightward motion in the point. On point motion trials, the frame remained stationary and the point moved 9° rightward. Thus, the perceived point motion on both kinds of trials was rightward. All motion was sinusoidal with a peak velocity of 0.5°/s. On both kinds of trials, when the moving stimulus reached its extreme position, the visual display disappeared so that nothing was visible and either the left or right auditory signal was activated. The sound was audible for 2 s. Observers were instructed to fixate the point, to track it if it moved, and then to move their eyes as rapidly and accurately as possible to the position of the sound when it occurred. Observers also reported whether the point appeared to move and the direction of its motion at the end of each trial. There were four frame motion trials and four point motion trials. Two of each of these kinds of trials were paired with the left auditory signal and two with the right. These eight trials were randomly presented.

The eye-tracking goggles were then removed, and the observers were given a brief rest. The eight trials were then repeated in a different random order, but now

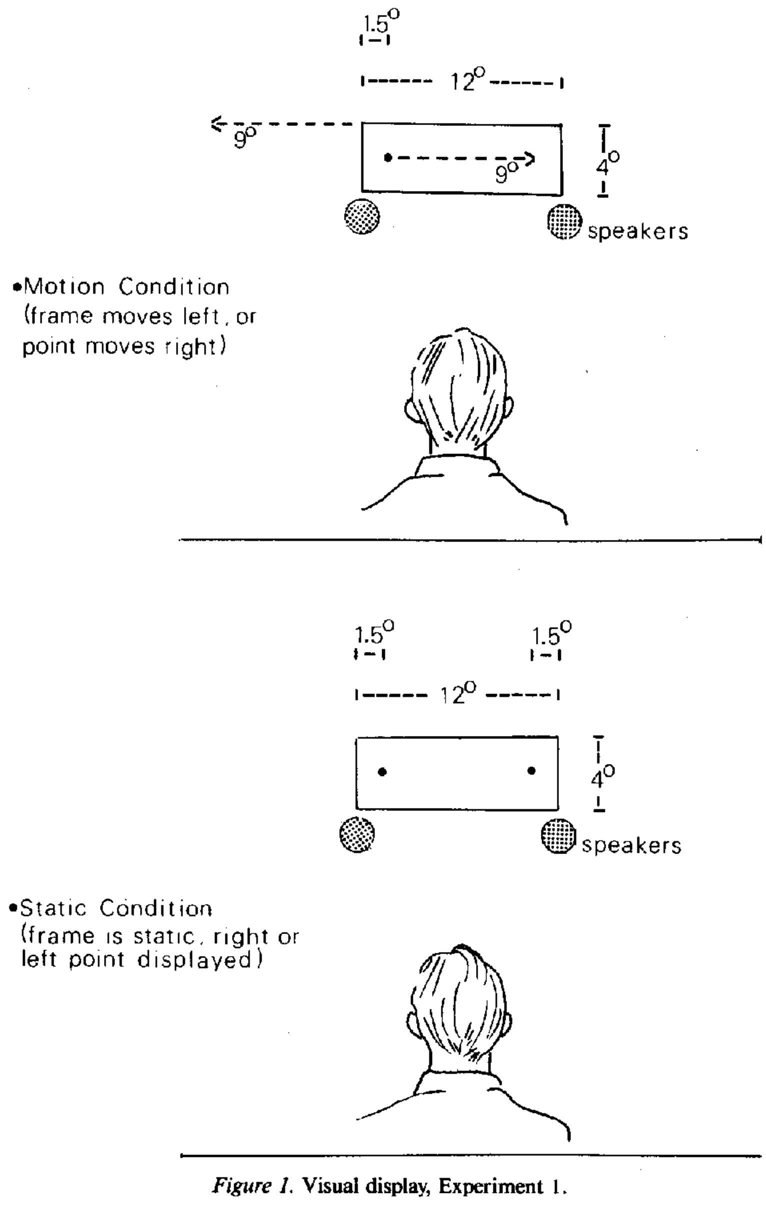

Figure 1. Visual display, Experiment 1.

observers were instructed to inform the experimenter when a point, which appeared on either the left or right of the screen immediately after the motion display disappeared, was aligned with auditory signal. The experimenter slowly moved the point until the observer judged its position to be correct. These trials served to establish that auditory localization was adequately accurate (+/−3°).

The four concluding trials in the motion condition were motion measurement trials, which provided estimates of the extent of the perceived motion of the point. Two of these involved point motion, and the other two involved frame motion. They were presented in a random order. Two points appeared on the screen immediately following the elimination of the motion display; they were adjusted so that the distance between them reflected the distance through which the point had appeared to move.

Static condition. This condition served as the control for the motion conditions. In this condition the frame was always centered around the subjective straight ahead. The point was displayed within the rectangle either 1.5° inward of its left or right edge. When on the left, its position was identical to the point's position during the induction trials; when on the right, it was identical to the point's position at the conclusion of a point motion trial (see Figure 1). The display was static and visible for 20 s. Observers fixated the point and then saccaded to the sound which occurred immediately after the visual display disappeared. There were eight trials which were made up of two of each of the four possible combinations of speaker (left or right) and point positions (left or right). As in the motion condition, these trials were followed by a second set of eight trials in which the observer indicated when a movable point was aligned with the auditory target.

Results

As anticipated, frame motion effectively induced motion in the stationary point. Because we found no difference between the mean perceived extent of IM (M = 7.6°, SD = 1.2°) and actual point motion (M = 8.3°, SD = .86°), we may conclude that the induction was complete. The check on the accuracy of auditory localization provided by trials in which a visible point was aligned with the sound indicated that, in fact, localization was accurate within 3°. The mean deviations from accuracy in the various display conditions, both static and moving, ranged from 1.2° (SD = 0.56°) to 3.1° (SD = 1.7°).[3] With this in mind, we proceed to the evaluation of the eye-movement data to determine whether it provides evidence of capture.

The mean amplitude of the saccades on the various types of trials in the motion and static conditions and the mean deviations from accuracy are reported in Table 1. Because the initial and terminal positions of the eye provided the basis for the calculations of saccade amplitude, the amplitude and deviation from accuracy data are essentially identical.

A number of predictions concerning the similarities and differences among these means follow from the visual capture hypothesis. For example, if capture occurred, then on induction trials saccades to the left speaker must be significantly longer than those to the right speaker. The deviations from accuracy should indicate undershoot to the left and overshoot to the right, even though all these saccades are initiated from a fixation point 1.5° from the left speaker and 10.5° from the right one. Because the induction target has appeared to move about 8° rightward, full capture would imply that the position of the eye is registered about 8° to the right of its actual position, which would place it much closer to the right speaker than the left one. Further, if capture occurred, there should be no significant difference between the amplitude of saccades to the left speaker on induction and actual point motion trials and no difference in deviations from accuracy, even though these saccades are initiated from spatial positions separated by 9°. By the same reasoning, we can expect no difference between either the amplitudes or the errors of saccades to the right speaker on induction and point motion trials, even though here too the saccades are initiated from very different positions in space.

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[3] It may be possible to consider trials in which the observer was asked to align a visible point with the sound, following observation of IM as a test of the visual capture hypothesis. Because only the point was visible, its position ought to be given only by eye-position and retinal-position information. If capture occurred and eye-position information were misregistered, then the alignment of point and sound would indicate this in the same way as saccades to the sound. However, it seemed possible that the saccade from induction target to visible point following perceived induction might dissipate whatever capture occurred. This is why we did not make any inferences concerning capture from these results. If we are mistaken, and inferences about capture are legitimate, the results would be strong evidence against its occurrence. There were no significant differences in deviations from accurate alignment between motion and static trials.

Table 1
Mean Amplitude and Error of Saccades in Experiment 1

Stimulus condition	Speaker position: Left	*SD*	Right	*SD*
Mean amplitude of saccades				
Frame move (induced)	6.03°	3.50°	10.40°	2.40°
Point move (actual)	14.00°	3.80°	4.20°	1.80°
Static fixate				
Left	3.20°	1.30°	11.60°	2.80°
Right	12.40°	3.00°	4.70°	2.10°
Mean saccadic error				
Frame move (induced)	4.53°	3.50°	−0.09°	2.40°
Point move (actual)	3.54°	3.50°	2.73°	1.80°
Static fixate				
Left	1.66°	1.30°	1.08°	2.80°
Right	1.89°	3.00°	3.21°	2.10°

Note. SD = standard deviation. Positive numbers signify overjump; negative numbers signify underjump.

A set of predictable differences and equivalences between the motion and static conditions also follow from the capture hypothesis. For example, the amplitude and deviations from accuracy of saccades to the right speaker on induction trials should be equivalent to those to the right speaker on static trials when fixation is on the right, even though the positions from which these saccades start differ by 9°. On the other hand, saccades to the left speaker should be significantly longer on induction trials and the error significantly greater than on static trials when fixation is left even though these saccades are initiated from the same position. Table 2 presents the entire pattern of expected differences in saccadic amplitude among the various conditions based on the capture hypothesis. (These are made without regard for the direction of the saccades.)

Both inspection and analysis of the results indicate that the actual obtained pattern of saccades was essentially opposite to that expected on the basis of capture. The outcome of a two-way analysis of variance (ANOVA) using the amplitude data with one between-subjects factor (motion vs. static) and one within-subjects factor (the conjunction of saccade start position and speaker position) provides no support for the capture hypothesis. Contrary to the capture prediction, there was no significant main effect of motion $F(1, 19) = 0.98$. In other words, there were no significant differences in amplitude or error that were a function of whether or not the display was moving or stationary. The other factor, however, produced a highly significant main effect, $F(3, 60) = 77.04$, $p < .001$, but this was to be expected whether or not capture occurred because of the differences in speaker position and position of the eye from which

Table 2
Tests of Predictions for Experiment 1

Predicted differences	Obtained differences
Motion trials	
1. Induction; sound left > induction; sound right	−3.59**
2. Induction; sound left = point moves; sound left	−7.15***
3. Induction; sound left > point moves; sound right	1.41
4. Induction; sound right = point moves; sound right	11.29***
5. Induction; sound right < point moves; sound left	−3.19*
Static trials	
6. Induction; sound left > point left; sound left	2.40*
7. Induction; sound left = point left; sound right	−3.81**
8. Induction; sound left > point right; sound right	1.00
9. Induction; sound left = point right; sound left	−4.23***
10. Induction; sound right = point left; sound left	7.95***
11. Induction; sound right < point left; sound right	−.95
12. Induction; sound right < point right; sound left	−1.54
13. Induction; sound right = point right; sound right	5.51***

Note. Predictions based on visual capture hypothesis made with regard to amplitude but not with regard to direction of saccades. The right-hand column gives the studentized *t* value and significance level of the obtained difference.
* $p < .05$. ** $p < .01$. *** $p < .001$.

saccades were initiated. The interaction between the two factors also proved significant, $F(3, 60) = 3.39$, $p < .05$, but this has no implications for the capture hypothesis. Post hoc comparisons of all the relevant means provide strong support for the conclusion that no capture occurred. The outcome of these various comparisons is reported in Table 2 to the right of the capture predictions. Note that although the comparison listed in Line 1 is significant as predicted, the difference is opposite that predicted by the capture hypothesis. As expected, if saccades were accurate on induction trials, saccades to the left speaker were significantly shorter than those to the right.

The comparisons listed in Lines 5 and 6, which are both significant, are the only obtained differences that conform to the capture predictions. However, in our view, these differences have a far more likely explanation based on the fact that subjects in the motion condition tended to make longer saccades to the left than to the right. That is, when the saccade was from the left to the left speaker (frame move condition) or from the right to the left speaker (point move condition), the saccades were longer than when they were from the right to the right speaker (point move condition) or from the left to the right speaker (frame move condition). This difference is apparent in both the amplitude and error scores. We believe this difference accounts for finding Comparisons 5 and 6 significant. This is why, we believe, saccades to the left speaker on point motion trials initiated 10.5° to the right of the speaker were longer (14.0°) than those to the right on induction trials where the saccade is initiated from a position 10.5° to the left. In fact, in the induction case, the saccades are quite accurate. Similarly, the fact that saccades to the left speaker on induction trials are longer than they are on static trials when the fixation point is on the left also seems to be only a consequence of the fact that the observers in the motion condition made longer leftward saccades; that is, they tended to overshoot the target regardless of whether motion was actual or induced when saccading leftward.

All the other obtained similarities and differences are precisely what would be expected if saccades were accurate and eye position was correctly registered. The fact that the results of 11 of the 13 comparisons are opposite to those predicted by the capture hypothesis and the 2 comparisons that produced predicted differences seem to have a more likely explanation provides compelling evidence for the conclusion that IM is not associated with visual capture of eye-position information.

The final two experiments were designed to determine whether the perception of IM causes a straight ahead shift. This question takes on added significance, given the failure to find evidence of visual capture. Evidence of a straight ahead shift might account for the frequent judgment that a stimulus in which motion has been induced appears to move egocentrically.

Because every effort was made to minimize the possibility that the critical eye movement might be dictated by the observer's wish to behave in a self-consistent manner, the eye-movement target was not directly related to the IM display. It was also not visually marked. Because we are concerned with the possible occurrence of a straight ahead shift, the target position selected was the subjective straight ahead. Observers were required to look to this position following fixation of a stationary stimulus offset from straight ahead in which motion was induced. Preliminary testing confirmed that observers could reliably and accurately saccade to this position from a stimulus offset to the right or left when straight ahead was not marked by a visual stimulus. We reasoned that because the critical eye movement was not to a stimulus that suffered the IM, the observers would not feel compelled to execute an eye movement consistent with the perceived IM in order to remain self-consistent. On the other hand, if IM causes a straight ahead shift, the saccade to straight ahead following fixation on the induction stimulus should reflect this. Thus, if a stationary induction stimulus, which is offset to the left, appears to move further left, the subsequent saccade to straight ahead should place the eye to the right of true straight ahead by an amount equal to the extent of the perceived IM.

Experiment 2A

Method

Subjects. Eight observers with normal, uncorrected vision who were unfamiliar with the phenomenon of IM were paid for participation in the experiment.

Apparatus and visual display. The visual display was presented on a fast phosphor (P15) CRT. It consisted of a 3° × 12° rectangular contour which enclosed a single point. As in Experiment 1, both this point and the horizontal midline of the rectangle were at eye level. At the outset of a trial, the point was located 3° to the left of the right edge of the rectangle. The rectangle was 3° to the left of subjective straight ahead (see Figure 2), so at the outset the enclosed point was 6° to the left of straight ahead. (Apparent straight ahead was determined prior to testing using the procedure described later.) During a trial either the rectangle or point oscillated through a distance of 6° at 0.05 Hz (average velocity: 0.6°/s; peak velocity: 0.85°/s.) The frame oscillated from its initial position to the right and back inducing an opposite motion in the stationary point. When the point actually moved, it oscillated to the left and back. Because the motion of the frame and point were opposite in direction, the perceived direction of the IM was the same as the perceived direction of the actual motion of the point. A trial consisted of either one and a half or two complete cycles of motion, after which the entire visual display disappeared, leaving the screen dark and nothing visible. When the stimulus motion covered two full cycles, the display disappeared when the moving stimulus

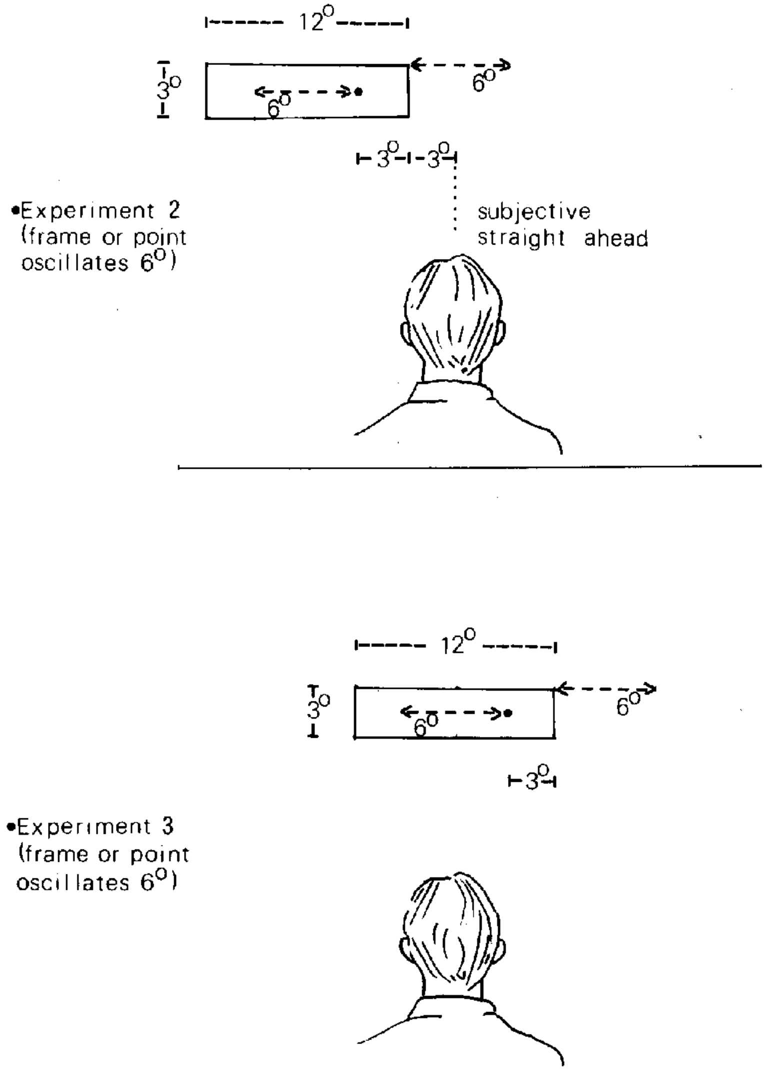

Figure 2. Visual display, Experiments 2 and 3.

returned to its initial position. With one and a half cycles of motion, the display blanked when the moving stimulus reached its extreme position. If the perceived IM entails an equivalent shift in straight ahead, then on all trials involving one and one half cycles of motion, the point should appear to have moved 6° further to the left of straight ahead when the display disappears.

Design. There were eight induction trials in which only the frame moved and eight trials in which only the point moved. Half of the trials in each of these conditions involved two full cycles of motion and half involved one and a half cycles of motion. Trials were presented in a predetermined random sequence. Observers were required to look straight ahead as soon as the visual display disappeared.

Procedures. Observers viewed the display from a distance of 45.7 cm in complete darkness while their head position was maintained by a dental impression bite plate. Eye position was monitored by an SRI Double Purkinje Image eye tracker (Crane & Steele, 1978) and recorded on a four-channel polygraph. Prior to actual testing, a point located approximately straight ahead of the observer was presented along with the rectangle and enclosed point. Observers were asked to judge whether this additional point appeared straight ahead. If it did not, its position was adjusted to coincide with the position the observer judged to be straight ahead. Observers then practiced saccading to this position. Practice proceeded in three stages. The visual display was presented in its initial position. Observers were required to saccade from the point within the rectangle to the point marking straight ahead. Next, they practiced saccading to straight ahead immediately after the visual marker was blanked. Finally, they were required to saccade to the unmarked straight ahead position from the position of the enclosed fixation point when the entire display was blanked, which was the task during actual testing. Experimentation began when observers were able to perform this final task with a reasonable degree of accuracy (+/−1° from actual straight ahead), which in all cases required only minimal practice. Note that the observers were never practiced in saccading to straight ahead from the point's extreme position.

An actual testing trial began with the observer fixating the point enclosed by the rectangle. The observer's task was to maintain fixation on this stimulus as long as it was visible, to track it if it moved, and to look straight ahead as soon as the display blanked. Following this sequence, the observer verbally reported whether or not the point had appeared to move and the direction of motion. Between each eye-movement trial, the point marking straight ahead was redisplayed and the observer made a practice saccade to it from the stationary induction target. The observer then refixated the enclosed point, and the next trial was begun. After the 16 eye-movement trials were completed, there were 4 additional trials, which were designed to provide an estimate of the extent of the point's perceived motion. These trials comprised one trial from each of the four display conditions (one and a half or two full cycles of point or frame motion). On these trials when the visual display disappeared, two points—located either side by side or horizontally separated by 12°—appeared on the screen. The observer adjusted the distance between these points to indicate the distance through which the point had appeared to move. This adjustment was made by means of a potentiometer dial. If no point motion had been perceived, the observer simply reported this, and no adjustment was made.

Results

The outcome of the final four trials, which provide an estimate of the amplitude of the perceived motion of the point, is considered first because these results indicate whether the visual display effectively generated IM. No observer failed to report point motion on any of the eye-movement trials, strongly suggesting that the frame motion induced motion in the point. This is borne out by the results of the motion measurement trials summarized in Table 3. A 2 × 2 ANOVA (Motion Condition × Cycle Length) of these data indicated that there were no significant differences among the results from the four conditions. In other words the amplitude of the perceived IM of the point was equivalent to that of its perceived actual motion. The actual stimulus motion was 6°, and both the mean amplitude of the induced and actual motion of the point were close to 6°.

Table 4 summarizes the eye-movement data. If IM produces a straight ahead shift and it is equivalent to the IM, then saccades following the one and a half cycles of IM should be indistinguishable from those following one and a half cycles of actual point motion, because the perceived extent of motion did not differ. When the point moved, the display blanked when it had gone 6° to the left, which placed it 12° from straight ahead. Therefore, an accurate saccade should move the eye 12° to the right. On the comparable induction trials, the saccades should also move the eye 12° to the right. However, because the fixated induction stimulus had remained in its original position (6° to the left of actual straight ahead), this saccade should place the eye 6° to the right of actual straight ahead. Further, if a straight ahead shift occurs, saccades following two cycles of IM must differ from saccades following one and a half cycles even though the position from which the saccade is initiated is identical. Assuming that the straight ahead shift is complete, the expected difference should in fact duplicate the difference between saccades following one and a half and two cycles of point motion. With one and a half cycles of motion, the saccade should move the eye 12° to the right, whereas with two cycles of motion, the saccade should move it only 6°. No differences are expected between saccades following two cycles of induced or actual motion, because in both cases the display disappeared when it had returned to its initial position. Saccades in both cases should be 6° rightward.

Inspection of Table 3 suggests that the predictions based on the assumption of a straight ahead shift were realized, and this is supported by the statistical analysis of these data. A 2 × 2 ANOVA indicated that both main effects (frame vs. point motion; one and one half vs. two cycles of motion) and their interaction were significant. (The calculated F values are stated in the legend accompanying Table 3.) The post hoc comparisons, which allowed us to compare the mean saccadic amplitude in each of the four conditions with each of the other three means, yielded a significance pattern which, with one possible exception, supports the straight ahead shift hypothesis. When motion was induced, saccades following trials in which the display blanked with the point in its apparently far position were significantly longer than those that occurred after the point had apparently returned to its original position, $t(7) = 7.52$, $p < .001$. The mean position of the eye at the termination of the saccades from the apparently far position was (4.4°) to the right of straight ahead as opposed to only (0.15°) to the right when the saccade was initiated from the point's initial position. Thus, these eye movements appear to reflect a shift in the apparent straight ahead position analogous to the IM of the induction stimulus. The other expected differences were also obtained with one exception. A comparison of the mean amplitude of saccades following one and a half cycles each of point motion and frame motion indicated that the saccades following the IM were significantly shorter than those following actual motion, $t(7) = 5.27$, $p < .005$. Because the obtained measure of induced and actual motion were equivalent, if the straight ahead shift had been complete, the amplitude of these saccades should not have differed. Because they did, it is possible that this shift may have been less than complete.

Table 3
Summary of Psychophysical Data of Experiment 2A: Mean Judgment of Motion Extent

Stimulus condition	Display cycles: 2	*SD*	1½	*SD*
Point motion (actual)	5.8°	1.50°	7.6°	1.40°
Frame motion (induced)	5.7°	3.30°	6.7°	2.80°

Note. *SD* = standard deviation.

Table 4
Summary of Eye-Movement Data of Experiment 2B: Mean Amplitude of Saccades

Stimulus condition	Display cycles: 2	*SD*	1½	*SD*
Point motion (actual)	6.28°	1.60°	12.80°	2.10°
Frame motion (induced)	6.15°	1.50°	10.40°	1.80°

Note. *SD* = standard deviation. For actual/induced motion: $F(1, 7) = 16.03$, $p < .01$; Near/far cycle: $F(1, 7) = 69.3$, $p < .01$; Interaction: $F(1, 7) = 11.7$, $p < .05$.

Experiment 2B

A second version was performed using faster stimulus motions. This replication seemed merited because both Duncker's (1929) view of separation of systems, which is an integral part of his argument that IM is object relative, and Rock et al.'s (1980) and McConkie and Farber's (1979) view that IM is subject relative are based on conditions in which the inducing motions are well above the subject-relative threshold. The slower stimulus motion was originally selected to ensure a maximally strong IM.

Method

Subjects. Ten different subjects participated in this version.

Visual display. The rectangular frame was expanded to 16° × 4°, and the enclosed point was initially offset 8° to the left of straight ahead and 4° to the left of the right edge of the rectangle. As in the previous version, either the point or frame oscillated. The amplitude of motion was 8° and had frequency of 1 Hz (average velocity: 1.6°/s; peak velocity: 2.25°/s).

Procedure. All procedures were identical to those described earlier.

Results

The results are consistent with those of the earlier experiment, although the display conditions were somewhat less effective in generating strong IM. Two of the observers reported very small IM, and the mean perceived IM across all 10 observers was less than the mean perceived amplitude of actual point motion; this difference is not significant, however. The remaining 8 observers reported IM which was equivalent to the perceived actual motion. The amplitude of the mean perceived IM was 7.5° (SD = 3.12°), whereas the mean perceived amplitude of actual point motion was 9.1° (SD = 1.28°). If we assume that the obtained estimates of the IM are a fair representation of IM trial by trial, then if a complete straight ahead shift occurs, we should expect that on IM trials saccades from the apparently far position of the point should be approximately 7.5° longer than those from the apparent initial position. Table 5 presents the eye-movement data. Saccades from the apparently far position were an average of 2° longer than those from the apparent initial position. The mean amplitude of saccades from the apparently far position of the point was 11.42° (SD = 1.88°), whereas the mean amplitude of the saccades from the apparent initial position was 9.4° (SD = 1.6°). This difference, although less than anticipated on the basis of a straight ahead shift comparable with the perceived IM, nevertheless is significant, $t(11) = 4.68$, $p < .005$.

We again found that the mean amplitude of saccades to straight ahead following one and a half cycles of actual point motion was significantly greater than the mean amplitude following one and a half cycles of IM, $t(11) = 6.46$, $p < .001$. When the point actually moved, saccades from the far position were on average 16.4° and positioned the eye 0.6° to the right of straight ahead, whereas when motion was induced the comparable saccades were 11.4° and positioned the eye about 3.5° to the right of straight ahead. If both IM and the straight ahead shift had been complete, these saccades should not have differed in size. The fact that they do, and that the saccades in the IM trials from the apparent far position do not reflect the full extent of the perceived IM, again suggests that the straight ahead shift may not have been complete. The results of both versions of Experiment 2 therefore suggest the possibility that there may be some limit to the extent to which judged straight ahead may be shifted at least under stimulus conditions that generate IM. Further, if the straight ahead shift is less than the IM, the perception of IM is clearly independent of it.

Table 5
Summary of Eye-Movement Data of Experiment 2B: Mean Amplitude of Saccades (Fast Motion)

Stimulus condition	Display cycles: 2	SD	1½	SD
Point motion (actual)	9.02°	2.07°	16.43°	2.03°
Frame motion (induced)	9.40°	1.60°	11.42°	1.88°

Note. SD = standard deviation. For actual/induced motion: $F(1, 9) = 55.12$, $p < .001$; Near/far cycle: $F(1, 9) = 222.95$, $p < .001$; Interaction: $F(1, 9) = 22.5$, $p < .005$.

Experiment 3

In Experiments 2A and 2B the amplitude of saccades to straight ahead was expected to differ if IM caused a straight ahead shift. In this experiment it is the direction of the saccade that is expected to differ if a shift occurs. The expectation that the saccade will move the eye in the wrong direction, rather than by the wrong amount, provides a different and perhaps more severe test of the straight ahead shift hypothesis. The enclosed point was now located to the right of subjective straight ahead. When motion was induced, it appeared to move leftward. Therefore, if a straight ahead shift occurs, the saccade to straight ahead should move the eye to the right, placing it even further to the right of true straight ahead.

Method

Subjects. Nine observers, none of whom had participated in an experiment on IM, were tested.

Visual display and procedure. The procedure and display were similar to those used in the first version of the preceding experiment. However, the 3° × 12° rectangle was initially centered around the subjective straight ahead and the enclosed point was 3° to the right of straight ahead and therefore 3° to the left of the right side of the rectangle (see Figure 2). The amplitude of stimulus oscillation was again 6° at 0.05 Hz. On induction trials, the rectangle oscillated 6° to the right and back to its initial position, causing the point to appear to move 6° to the left when induction was complete. On point motion trials, the rectangle was again stationary, and the point oscillated to the left. The trials in each of these conditions were equally divided between two full cycles of motion and one and a half cycles. With two cycles the display blanked in its initial position so that all saccades to straight ahead should move the eye 3° to the left. With one and a half cycles of motion, the display blanked in its extreme position, therefore an accurate saccade in the condition in which the point moves should carry the eye 3° to the right. Because in the induction condition the point does not actually move, an accurate saccade to straight ahead must still move the eye 3° left. However, if induction is complete and there is a comparable straight ahead shift, judged straight ahead should be shifted 6° rightward and therefore should appear to be 3° to the right of the induction stimulus. Thus, a saccade to straight ahead should carry the eye 3° to the right, which would place it actually 6° to the right of true straight ahead. All remaining procedures were identical to those of the earlier experiment.

Results

Data from the four concluding trials measuring the perceived motion indicated that there was no difference between the perceived induced and actual motion of the point. The mean perceived extent of IM was 7.5° (*SD* = 1.35°), and the mean perceived extent of actual motion was 7.4° (*SD* = 1.76°). (Because actual stimulus motion was 6°, the perceived motion was somewhat overestimated.) If a straight ahead shift occurs and is complete, the amplitude of saccades following one and a half cycles of IM should not differ from those following one and a half cycles of actual point motion, although the position of the eye at the termination of these saccades differs by 6°. In both cases the saccade should move the eye 3° to the right. However, when motion is induced, this will place the eye 6° to the right of straight ahead, whereas when the point actually moves this saccade will position the eye accurately.

Tables 6 and 7 summarize the eye-movement data. Both the mean amplitude of the saccades (Table 6) and the mean positions of the eye at the termination of the saccades (Table 7) are given.[4] The accompanying legends report results of the ANOVAs performed on these two sets of data. When motion was induced and the display blanked in the extreme position, the saccade moved the eye an average of 2.5° further to the right of straight ahead, bringing the eye about 5.6° to the right of actual straight ahead. In the remaining three conditions, the saccades positioned the eye appropriately within about 0.5° of straight ahead as expected. Post hoc comparisons of the mean positions of the eye at the termination of the saccades indicated that its position following one and a half cycles of IM differed significantly from each of the three other means. Although there was no significant difference between the amplitude of saccades following one and a half and two cycles of point motion, saccades following one and a half cycles of IM were again significantly shorter than saccades following one and a half cycles of actual point motion ($t(8) = 3.99$, $p < .005$). This parallels the findings of both versions of the previous experiment, again suggesting the possibility that the straight ahead shift may have been less than complete, a suggestion supported by the fact that saccades following one and one half cycles of IM were significantly shorter than those following two cycles, $t(8) = 2.5$,

Table 6
Summary of Eye-Movement Data of Experiment 3: Mean Amplitude of Saccades

Stimulus condition	Display cycles: 2	*SD*	1½	*SD*
Point motion (actual)	3.39°[a]	0.79°	3.46°[b]	0.63°
Frame motion (induced)	3.07°[a]	0.68°	2.46°[b]	0.72°

Note. SD = standard deviations. For actual/induced motion: $F(1, 8) = 18.15$, $p < .01$; Near/far cycle: $F(1, 8) = 1.50$, $p = ns$; Interaction: $F(1, 8) = 6.78$, $p < .05$.
[a] Leftward saccades. [b] Rightward saccades.

[4] Because the visual capture hypothesis predicts a difference in the direction of the saccades rather than amplitude, both the terminal position of the eye at the end of the saccade and size of the saccade are presented.

Table 7
Summary of Eye-Movement Data of Experiment 3: Mean Endpoint of Saccades

Stimulus condition	Display cycles 2	SD	1½	SD
Point motion (actual)	0.40°[a]	0.84°	0.30°[b]	0.63°
Frame motion (induced)	0.10°[a]	0.72°	5.61[b]	0.07°

Note. SD = standard deviation. For actual/induced motion: $F = (1, 8)\ 666.36$, $p < .001$; Near/far cycle: $F(1, 8) = 70.78$, $p < .001$; Interaction: $F(1, 8) = 252.99$, $p < .001$.
[a] Degree to left of straight ahead.
[b] Degree to right of straight ahead.

$p < .05$. Whether or not it was complete, however, this measure suggests that it occurred, even when this entailed an eye movement in a direction opposite the intended goal.

Discussion

Straight ahead shift. In Experiment 1 it was found that saccades to auditory targets following fixation upon a stationary stimulus that undergoes an IM are unaffected by the IM. This conclusion would seem to establish that the shifts in saccades to straight ahead obtained in Experiments 2A, 2B, and 3 are clear evidence of a straight ahead shift. The telltale sign of a straight ahead shift is that only tasks involving the straight ahead are affected, and this is the case here.[5]

The shifts in the judgment of where straight ahead lies, reflected by the saccades following perceived IM in the second and third experiments, appear to have been caused by the egocentrically asymmetric position of the surround which displaced straight ahead toward its center. This therefore seems to be an instance of the Roelofs Effect (Roelofs, 1935). Consistent with this conclusion is the fact that the Roelofs Effect and the effects measured in Experiments 2A, 2B, and 3 were partial. All previous investigation of the Roelofs Effect indicates it is not complete (see Howard, 1966, for a discussion of these findings). Indirectly these results confirm Harris's speculation that the Roelofs Effect is an instance of the straight ahead shift and is not perceptual in character.

If, as it appears, the apparent shift in egocentric position associated with IM (revealed by pointing to the induction target and saccading to straight ahead) is a function of a judgmental rather than perceptual process, then it seems highly likely that it is a by-product rather than a cause of IM. If true, then Brosgole's account of IM must be mistaken. This should not be interpreted to mean, however, that the perception of IM does not entail a perceived shift in the position of the induction object. It means only that this shift in position is with respect to the visual surround, not the observer.

Object versus subject-relative motion. The combined results of these three experiments argue strongly against the view that IM is subject-relative motion. The fact that the registration of eye position appears to be unaffected by the perception of IM means that Rock et al.'s (1980) and McConkie and Farber's (1979) explanation of IM cannot be correct, at least insofar as they depend on the assumption of oculomotor visual capture. Recall that according to Rock et al., IM of a stationary object is motion subtracted from the actual subject-relative motion of the inducing surround, which occurs because there is a "strong preference to attribute the relative displacement between a spot and surrounding frame to the motion of the spot" (p. 393). The authors then asserted the visual capture hypothesis:

> To rationalize such phenomenal motion in the spot despite subject-relative information that there is no such motion, observers interpret their eyes as tracking the "moving" spot. Duncker (1929) reported that observers do in fact interpret their eyes as moving even when fixating the stationary spot . . . drift of the surround could be attributed by the perceptual system to eye movements and thus account for the induced motion of

[5] One might wish to consider the results of Experiment 1 inconclusive on the grounds that auditory localization is interchangeable with retinal localization; therefore, saccades to auditory targets would not depend on eye-position information any more than saccades to retinally defined targets do. This would, of course, account for the failure to find visual capture in Experiment 1. This reasoning is wrong, however, because auditory localization is necessarily based on headcentric coordinates.

the surrounded object. Such an effect can be considered an example of visual capture. (Rock et al., 1980, p. 393)

As noted earlier, this visual capture argument appears in an article by McConkie and Farber (1979) which describes the perceptual effects of observing bidirectional, uniform velocity fields that are classified as instances of IM.

There is nothing new about the claim that there is (in effect) some form of compensation for motions of the eye. . . . We suggest that such compensation is based on registered, rather than actual, motions of the eye. Given spurious optical information about ongoing smooth motion of the eye, the compensatory processes normally involved in processing optical motions would account for the perceptual effects observed in these experiments. . . . Retinal displacement of a frame of reference corresponds directly to visual kinesthesis for rotation of the eye. (McConkie & Farber, 1979, pp. 507–508)

Because there does not appear to be any visual capture of eye-position information, accounts that maintain that visual capture underlies IM cannot be correct. Further, Gibson's notion of sensationless proprioception seems to be disconfirmed as well, at least in relation to oculomotor information. The fact that observers nevertheless report they are tracking the physically stationary induction object therefore must be the consequence of a judgmental rather than a perceptual process. Because observers perceive motion in the point they are fixating, they consciously conclude that they must be tracking it even though the eye's actual behavior is correctly registered.

Because the results of the first experiment rule out the possibility that IM is based on headcentric coordinates which would require the visual capture of eye-position information, we agree with Duncker that IM is object-relative motion based on the distance change between the surrounding and surrounded objects. Moreover, although these experiments were not designed to test Duncker's concept of separation of systems, they nevertheless support it. Duncker proposed that the motion of the surround and the IM of the enclosed object occur in separate systems, one subject relative, the other object relative. Because our results are evidence that IM is object relative, they provide indirect support for this hypothesis.

IM of the self (vection). The failure to find visual capture of eye-position information is somewhat puzzling in view of recent reports that the cells of the vestibular nuclei of the rhesus monkey respond in the same way to real and illusory self-motion (Henn, Young, & Finley, 1974) when the illusion of self-motion is induced by the motion of a large moving surround. This phenomenon of IM of the self, now often referred to as *vection,* was first described by Duncker (1929). Duncker believed that this phenomenon was based on a process very similar to that underlying induced object motion. Induced self-motion, like induced object motion, for Duncker was based on a continuous distance change between an enclosed object and a moving surround, but in the case of induced self-motion it is the observer who is the enclosed object. If Duncker is correct, then it would seem to follow that because vection appears to be associated with the visual capture of vestibular signals, induced object motion ought to be associated with visual capture of oculomotor signals. That is, one might reasonable expect that the cortical cells which fire when the eye is actually tracking a moving object would fire when the eye is fixating the apparently moving induction object. (The reader is referred to Howard, 1982, for a discussion of the cortical activity associated with pursuit.) Although this particular question does not seem to have been investigated, our failure to find evidence of visual capture of oculomotor information makes this outcome unlikely.

IM and pointing. The results of these experiments are consistent with the finding that open-loop pointing to a stimulus that undergoes IM is undistorted by the perceived IM (Bridgeman et al., 1981) and inconsistent with the report that IM either completely (Farber, 1979) or partially (Bacon et al., 1982) determines the orienting response. Because according to Harris, pointing with an unseen hand at a visual stimulus is not among the tasks affected by the straight ahead shift, the reports of the influence of IM on pointing or manual tracking are difficult to explain. Perhaps they belong in the category of demand characteristic effects. That is, perhaps they are effects that are a consequence of the observer's wish to remain self-consistent or to oblige the experimenter. After all, the observer has seen the induction target move and may feel that pointing must reflect this.

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Psychological Documents to Be Discontinued

At its February 2–3, 1985, meeting, the Council of Representatives voted to cease publication of *Psychological Documents* (formerly the Journal Supplement Abstract Service) as of December 31, 1985, with the publication of the December 1985 issue of the catalog. Continued low submissions, decreasing usage, and rising costs for fulfillment of paper and microfiche copies of documents were reasons given for discontinuing publication of the alternative format publication, which was begun in 1971 as an "experimental" publication.

Authors who wish to submit documents for publication consideration must do so by July 1. Authors who are currently revising documents at the request of the editor should complete all revisions and submit them for final review as soon as possible, but no later than July 1. Orders for paper and microfiche copies of documents presently in the system and of those documents entered during 1985 will continue through December 31, 1986.
