The role of eye movements in the perception of visually induced autokinesis

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Changes in eye position were recorded physiologically while S experienced visually induced autokinesis. Eye movements did not seem to sufficiently explain this phenomenon. Apparent motion was found to be based upon a change in phenomenal rather than retinal location. Special consideration was given to those parameters possibly responsible for paradoxical motion.

Laterally induced autokinesis was demonstrated by Brosgole (1967) in an attempt to relate visually perceived movement to egocentric spatial displacement. In essence, S fixated a stationary luminous target, in total darkness, surrounded by a rectangular frame which moved from left to right, in one instance, and from right to left in another. As the frame displaced to the right, for example, the apparent median plane shifted along with it—inducing the target to move to the left. The frame was occluded upon reaching the end of its travel, permitting the subjective straight ahead to return back to true center. As a result, the target autokinetically drifted from its initial position on the left to a phenomenally straight ahead location. The opposite obtained when the frame journeyed to the left. Changing the location of a target relative to the apparent median plane, then, appeared to be sufficient for inducing autokinesis horizontally.

Brosgole and Cristal (1967) subsequently found that inducing the apparent eye level position to shift in an up-down direction resulted in autokinesis vertically. In addition, Jordan (1967) related autokinesis to the factor of egocentric displacement, permitting free-style inspection of the stimulus. His data indicated that subjective location change seems to be necessary, not merely sufficient, for the perception of autokinesis.

It has been argued (e.g., Matin & Mackinnon, 1964) that autokinesis is based upon a change in the retinal location of an isolated visual stimulus, generated by unmonitored shifts in eye position. Thus, the phenomenological explanation offered above could be reduced to an ultimate physiological cause.

Accordingly, the following experiment was designed to assess the role of retinal and egocentric displacement. Autokinesis was induced laterally (as described above) with the intent of determining whether there was an associated equal and opposite horizontal drift of the eye, or a change in the subjective straight ahead.

METHOD

The logic of this study demanded apparatus for generating autokinesis and recording the amount of apparent motion, as well as equipment for plotting the precise position of the eye. Each will be described separately below.

Apparent Motion Apparatus

The apparatus consisted of a wooden frame, 5-½ ft high and 6 ft long, a variable speed DC motor, a system of pulleys and a horizontally traveling screen (60 in. high x 30 in. wide) upon which stimuli could be mounted. The screen was driven back and forth along a set of tracks by the motor via the pulley system. It traveled 10 deg 20 min (22 in.) at a rate of 20 min, of visual arc per sec. Once reaching the end of its 22-in. journey, 31 sec later, the screen activated a relay reversing the motor and, as a result, its direction of travel. Thus, once the remotely operated motor was started, the screen took a continuous trip back and forth across space.

A Selsyns synchronous motor was mounted on the left side of the apparatus with a pulley secured to its shaft. A 10 turn, linear potentiometer, with a pulley of the same specification anchored to its shaft, was fastened to the right side of the apparatus. A visual target was hooked onto a belt which joined the two pulleys.

S remotely controlled the Selsyns motor by turning a knob affixed to the shaft of a duplicate motor which was mounted in a minibox. Thus, within 10 turns of the control knob, S was able to laterally move the target 60 in. across space while simultaneously adjusting the potentiometer from 0-1000 ohms resistance. A DC voltage was placed across the coil of the pot with leads from the armature and one terminal feeding through a Brush high gain DC amplifier into a Brush analog strip chart recorder. Changes in the horizontal location of the target effected by S were thereby translated into voltage outputs and concurrently charted.

Stimuli

The stimuli consisted of a 3/8 in. diameter circular spot of light surrounded by a 24 x 30 in. horizontal rectangular frame with 1-1/8 in. wide borders. The circular target was fastened to the belt and, therefore, under S's control, while the frame was attached to the screen varied by E. They were both constructed of Sylvania, white, electroluminescent Tape-Lite which basically served two advantages. For one, their brightness was regulated by varying the AC input with the target set at 1.8 and the frame at .009 ft-L. And, for another, it permitted the design of circuitry which enabled the reversing mechanism in the apparatus to turn the frame and target on and off independently in a manner designated by E in advance of each trial.

Biopotential Recording System

The horizontal position of the eye was ascertained by monitoring discrete changes in the corneo-retinal potential. The system, employing Beckman skin electrodes in conjunction with Brush and Tektronix equipment, has been fully described elsewhere (Brosgole, Cristal, & Carpenter, 1968). It was calibrated for each S by the use of perimetry and found to be linear within ± 40 deg of eye rotation with a capacity to resolve as little as ¼ deg of movement. S's participation in this study was contingent upon meeting certain rigid criteria relating to problems of voltage offset and long term drift.

Procedure

The experiment took place in a totally darkened room with the recording equipment located in an adjacent control room. The two were linked together by a voice communication system. The electrode leads passed from S through a network of light locks into the control booth. The S sat 10 ft in front of the apparent motion apparatus with his head positioned in a Bausch and Lomb head and chin rest. The chin rest was adjusted so that the circular target was at eye level.

The experiment consisted of three conditions. The first was aimed at assessing the amount of autokinesis induced in the target. With the center of the frame and target set in S's objective median plane, S was directed to fixate the target and ignore the frame at all times. He was told that E could independently control the motion of both the target and frame so that one could be seen as moving and the other stationary, or both could move simultaneously in the same or opposite directions. (Of course, E was able to manipulate only the frame.) S was further advised that he, too, could control the motion of the target by turning the control knob appropriately. His task was to cancel out whatever motion E might impose upon the target, so as to hold it frozen in space or perfectly stationary. Accordingly, an apparent leftward movement of the target yielded an adjustment to the right and vice versa. Thus, the amount of apparent movement was gauged through such a compensatory tracking procedure. After S demonstrated an understanding of the instructions, the surround was set into motion.

The frame displaced from center to the right by 11 in., inducing the target to move to the left. Upon reaching the end of its travel, it reversed direction and was extinguished. This resulted in an autokinetic drift of the target back to true center. The surround appeared at its extreme left position, 31 sec later, and remained visible while displacing off to the right. It took a total of 62 sec for the frame to move from center to the right, back through the center to the left and back to the center again, being visible only half the time. The S's adjustment of the target was recorded for five such cycles or trials.

The procedure was again repeated, but with the frame visible while displacing to the left, instead of the right. The order of these two sequences was varied from S to S.

Since the presence of the frame induced motion away from the objective median plane, and its occlusion generated autokinesis back to true center, the two sequences were statistically combined. That is to say, the amount of motion induced to the left and right of the medial axis of the body was algebraically summed. The same obtained for the amount of autokinesis perceived. This facilitated separate consideration of the two phenomena.

The second condition was identical to the first, except that S no longer was permitted to adjust the target. His sole task was to fixate upon it, ignoring the laterally displacing frame at all times. Therefore, the target remained perfectly stationary in the objective median plane. This enabled us to determine whether there were changes in eye position which correlated with the apparent movement of the target in both direction and magnitude.

The third condition was directed at disclosing whether the apparent median plane tended to shift and if this, in fact, was related to the phenomenal movement of the target. Therefore, the target was occluded with S instructed to gaze directly straight ahead, ignoring the frame at all times. Changes in the subjective straight ahead were obtained, using the eye as a pointing instrument. The order of the three conditions was counterbalanced over Ss.

Subjects

Two males and one female participated in this study.[2] Ranging in age from 20-24, their mean age was 21.3 years. They were undergraduate students who were naive as to the purpose of the experiment.

RESULTS AND DISCUSSION

In Condition 1, the position of the target was noted when the frame was visible at its right and left extremes. The disparity between these settings represented the range of motion induced in the target. The amount of such apparent movement was averaged over trials and then across Ss. The extent of laterally induced autokinesis was derived in the same fashion. The target was induced to move 1.81 deg in a direction opposite to the frame. Occlusion of the background resulted in 1.19 deg of autokinesis toward the mid sagittal axis of the body.

In Condition 2, the eye tended to track along with the displacing visual frame by 0.51 deg. When the frame was extinguished, the eye returned back to center by 0.24 deg.[3]

In the third condition, the apparent median plane shifted with the surround by 1.59 deg. Omission of the background was followed by a return of 1.07 deg to center.

These findings indicate that apparent movement, both induced and autokinetic, cannot be explained in terms of involuntary fluctuations of the eye, at least in magnitude if not direction. Rather, the subjective motion of the target seems to be contingent upon an egocentrically determined position change in phenomenal space.

ADDENDUM

A separate note is warranted, for there was a 23 year old, female, graduate student who experienced paradoxical motion. The phenomenally dynamic target was seen to possess direction, extent and velocity. Yet, it seemed perfectly stationary. The fact that the apparent movement of the target lacked a displacement component was evident in the first condition, where no adjustments were made.[4].

The S's performance in Condition 3 indicated that the displacing surround markedly affected the apparent median plane. The presence of the frame shifted the subjective straight ahead by 2.28 deg. Its omission resulted in a return of 3.25 deg to center. In other words, S characteristically overshot true center when the background was extinguished. According to these data, the apparent motion of the target should have been accompanied by a profound sense of spatial displacement.

The results of Condition 2 are of particular interest, because they provide the basis for resolving the paradox. Having been instructed to fixate upon the target, S repeatedly attempted to pursue its apparent movement. The eye shifted in the direction of induced motion by 5.18 deg, and in the direction of autokinesis by 2.43 deg.[5]

As to the matter of integrating and interpreting these findings, it would seem that apparent movement was initiated by the factor of egocentric displacement. Once having perceived motion, S tried to follow the target. The ensuing change in retinal location conflicted, in direction, with the egocentric change of position. Thus, the feature of spatial displacement was cancelled out, with pure movement perceived as a residual effect.[6] Only further research can authenticate this most speculative proposition.

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NOTES

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2. Approximately 40 Ss were rejected because of an ever increasing problem of dc drift. Drift in the neighborhood of 800 UV per hour finally caused us to abandon this study and rip down the equipment for test and calibration.

3. The data tended to be marked by a random fluctuation of the eye about the central fixation target. The Ss were quite attracted by the frame going on and off at its extremes. There was a consequential sudden jump of the eye every time the surround reversed direction. Since the records were sampled at these points only, the impression is given that the eye tended to continuously drift in a direction opposite to the apparent motion of the target. Actually, this was not the case.

4. This was the first person to report paradoxical motion in well over 600 subjected to some type of induced movement paradigm.

5. It is interesting to note that the change in retinal location was in the same direction as the subjective motion of the stimulus. This is contrary to an eye movement interpretation of the phenomenon.

6. The perception of motion endured, unaltered by the cancelling effect, because it was the antecedent state of affairs which initiated the entire process.

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