Perception & Psychophysics
1979, Vol. 25 (1), 70-72

Notes and Comment

Acceleration information for prism adaptation need not be reafferent: A comment on McCarter and Mikaelian (1978)

LAWRENCE E. MELAMED
Kent State University, Kent, Ohio 44242

BENJAMIN WALLACE
Cleveland State University, Cleveland, Ohio 44102

and

BARBARA SEYFRIED
SUNY College at Oswego, Oswego, New York 13126

Numerous studies have shown that obtaining reafferent feedback (Held, 1961) from self-produced arm movement is not necessary for the occurrence of prism adaptation (e.g., Howard, Craske, & Templeton, 1965). On the other hand, the advantage of self-produced or "active" movement over "passive" movement in the adaptation induction procedure originated by Held is an extremely reliable finding (Held, 1965; Held & Gottlieb, 1958; Held & Hein, 1958). This procedure has the subject simply view his or her prismatically displaced hand as it moves back and forth across the visual field. The movement may be linear or curvilinear. The viewing background is typically unstructured, preferably homogeneous. The rhythm of movement is controlled by the beat of a metronome.

In a recent article, McCarter and Mikaelian (1978) argue that an essential ingredient in active movement is acceleration; that unless this acceleration is part of the concomitant reafference, adaptation will not occur. "Thus, with the Held type of exposure, reafference from self-produced arm movements must include a visual acceleration component for adaptation to occur (p. 25)." The implied argument here is that acceleration information is an essential ingredient of reafference, which in itself, is the source of the advantage of active over passive movement. No passive movement control group was used.

McCarter and Mikaelian demonstrated that when active-movement subjects performed lateral arm movements on a linear track, significant target-pointing aftereffects occurred only when the subject's movements were confined to the visual field. If the arm was allowed to leave the visual field during its excursions, adaptation was not significant. The argument was made that only the group with confined movement received visual information concerning changes in speed (acceleration) as the arm slowed down, stopped, and started up in a new direction at the end of each lateral movement. A difference between comparable groups was not found when movement occurred along a curvilinear track. McCarter and Mikaelian explained this latter data by showing that acceleration information (concerning a change in direction) was always present in both of the curvilinear movement groups.

It always can be argued, however, that it is the attentional requirements of active movement that distinguishes it from passive movement (Melamed, Halay, & Gildow, 1973). Active movement in the Held paradigm necessitates focusing attention on both visual and proprioceptive information concerning momentary arm position. There is continual tracking of afferent information. In the passive-movement condition, there is no need to even track afference from the joint receptors, even if that is the only proprioceptive system involved (Lackner, 1977; Singer & Day, 1966). This makes it much more likely that discrepancies about arm position in the information from the two sensory systems would be detected in the active-movement condition. In Melamed et al., similar adaptive shifts on a target-pointing task were obtained when the exposure task necessitated directed attention for both active- and passive-movement subjects. The attention manipulation involved the subject calling out the arm's position via a series of background numbers. When this attention task was absent, the active group showed significantly greater adaptation than the passive group. Such data clearly fails to support the argument that reafferent information concerning arm acceleration is the critical factor in the usual superior performance of active over passive movement in the Held paradigm.

Some data are presented below that relate to the initial finding of McCarter and Mikaelian, that in which adaptation occurred when the subject used lateral arm movements confined to the visual field. In obtaining the present data, both active and passive movement were used with a confined-movement exposure condition. It was expected that both movement procedures would be effective in producing aftereffects as they had been in Melamed et al. (1973). The contention here is that the importance

This research was supported by Grant MH-20504 from NIMH to the first author. Requests for reprints should be sent to Lawrence E. Melamed, Department of Psychology, Kent State University, Kent, Ohio 44242.

0031-5117/79/010070-03$00.55/0

of informational feedback from acceleration is not in its potential usage as reafference, as McCarter and Mikaelian indicate, but, rather, that a manipulation designed to keep movement confined to the visual field serves two interdependent purposes. First, it requires the subject to carefully attend to the movement. Secondly, the decelerating, stopping, and renewed accelerating at the end of each excursion provide an enhanced opportunity for the subject to detect differences between the visual and proprioceptive location of the limb. The manner in which the subject's hand was confined to the field of view in the following procedure was designed to emphasize the subject's need to attend to arm location in much the same manner as the number calling task operated in Melamed et al. (1973).

METHOD

Subjects

The subjects were 24 female undergraduates recruited from the introductory psychology sections. They received course credit for participating. Only subjects who did not wear corrective glasses were selected.

Apparatus

Each subject was seated at a small wooden table with her head securely positioned on a combination head- and chinrest. Throughout all experimental procedures, the subject wore welder's goggles with Risley rotating prisms attached to the front surface. Viewing was monocular with the left eye occluded. In front of the subject, on the table, was a rectangular wooden box, 49.5 × 77.5 cm and open on the side facing the subject. When the subject was to observe movements of her hand, it was placed in an aluminum holder that ran on an aluminum track on top of the box. Immediately behind the track was a wooden backboard, covered with a sheet of white tagboard that extended the entire width of the box. The subject's hand was visually coincident with the backboard. For the tests involved in measuring the aftereffects resulting from prism viewing of hand movement, another white tagboard was placed over the backboard. Three black lines, .4 × 15.2 cm and 5 cm apart, were centered on the tagboard. During these tests, the subject's hand was kept out of sight by being placed in a holder on an aluminum slide in the interior of the box. The location of the subject's judgment of a target line was determined by reading a value from a measuring stick that was attached to the interior slide and moved with it.

Design and Procedure

A 2 × 2 factorial design was employed. All movement was contained within the visual field as described below. The two factors were the movement mode, active or passive, during the exposure condition and the base orientation, right or left, of the prisms. Six subjects were randomly assigned to each of the four groups.

All experimental manipulations were conducted during a 10-min exposure period in which the subject observed her hand movements with the prism set at 20 diopters. On the preexposure and postexposure coordination tests, the subjects pointed at each of the three line targets five times in a randomized trial sequence. The prisms were worn at this time and set at 0 diopters. The subject's hand was out of sight as the internal slide was used for these measurements. During the exposure period, the subject's hand was placed on top of the apparatus in the external slide. The subject watched her hand as she moved it back and forth in the prescribed visual field (active condition) or had it moved for her by the experimenter (passive condition). In both cases, a metronome was used to regulate the movement to about 1 cycle every 10 sec. At the beginning of the exposure period, the passive-movement subjects were given a few minutes' practice in relaxing their arms and having the slide moved for them. Their eyes were closed. A comparable delay was given the active-movement subjects.

Before the subject opened her eyes, a metal yardstick was placed along the backboard of the apparatus. The subject was then instructed to open her eyes and report the numbers on the extreme left and right of their visual field (nearest ¼ in.). This determined her visual field. She then closed her eyes while the experimenter determined the exact dimensions of the movement field. In order to ensure that the subject's movement was always in the visual field, both edges of the visual field were brought in 5 cm (approximately 8°) towards the center of the field. This correction was thought to be necessary in case the visual field shifted laterally during the course of the exposure condition. It was also a precaution against any inexactness in measuring the field originally. Safeguards were also established against the subject's accidentally leaving the viewed field during a movement. During the subject's arm movements, the experimenter called out "stop" whenever the subject came to the edge of the determined movement field. The subject was also instructed to stop her movement if she saw her hand leave the visual field before the experimenter had told her to stop. Passive-movement subjects were told to instruct the experimenter to stop if the subject's hand appeared to leave the visual field.

RESULTS AND DISCUSSION

The data of this experiment were the adaptation aftereffects obtained by averaging the postexposure pointing response over all targets for each subject and subtracting the comparable preexposure measure. For purposes of analysis, aftereffects were considered positive when they were in the direction opposite to the lateral displacement produced by the prisms. An analysis of variance found neither the two between-subject factors, movement mode and base orientation of the prisms, nor their interaction significant. The means of the two movement groups were almost identical. The mean for the active group was 5.37° [$t(11) = 4.41$, $p < .01$], whereas that for the passive group was 5.39° [$t(11) = 4.42$, $p < .01$]. The orientation variable was used as a precaution against directional effects, and the analysis seems to indicate that such effects were not a major influence in this experiment. Since the visual field was adjusted for each subject individually, some concern could be raised considering their comparability for the two movement groups. The mean visual field for the active group was 25.77 cm whereas that of the passive group was 27.30 cm. The difference between these two means was not significant [$t(22) = 1.36$].

The data of the present study corroborate the finding of McCarter and Mikaelian that confining active movement to the visual field will produce sizable aftereffects using the Held procedure. The further finding that virtually identical aftereffects can be found when the movement is passive makes unlikely McCarter and Mikaelian's contention that reafferent acceleration information is crucial for prism adaptation.

The argument that we propose is simply that the subject's accelerated movement can be a potent source of information, both proprioceptive and visual, about arm position. The interpretation of prism adaptation offered here is that efference controlling arm movement is under the influence of a decision process that integrates all afferent information concerning arm position and would therefore reflect disparities in these inputs such as those that may be made apparent when the subject decelerates or accelerates his or her movement. A firmer picture of the importance of acceleration information in the Held paradigm awaits parametric evaluations in which the rate and frequency of this information is manipulated.

REFERENCES

Held, R. Exposure history as a factor in maintaining stability of perception and coordination. *Journal of Nervous and Mental Diseases*, 1961, **32**, 26-32.

Held, R. Plasticity in sensory motor systems. *Scientific American*, 1965, **213**, 84-94.

Held, R., & Gottlieb, N. Technique for studying adaptation to disarranged hand-eye coordination. *Perceptual and Motor Skills*, 1958, **8**, 83-86.

Held, R., & Hein, A. V. Adaptation of disarranged hand-eye coordination contingent upon re-afferent stimulation. *Perceptual and Motor Skills*, 1958, **8**, 87-90.

Howard, I. P., Craske, B., & Templeton, W. B. Visuomotor adaptation to discordant exafferent stimulation. *Journal of Experimental Psychology*, 1965, **70**, 189-191.

Lackner, J. R. Adaptation to visual and proprioceptive rearrangement: Origin of the differential effectiveness of active and passive movements. *Perception & Psychophysics*, 1977, **21**, 55-59.

McCarter, A., & Mikaelian, H. H. The role of acceleration information in prism adaptation. *Perception & Psychophysics*, 1978, **23**, 21-26.

Melamed, L. E., Halay, M., & Gildow, J. W. Effect of external target presence on visual adaptation with active and passive movement. *Journal of Experimental Psychology*, 1973, **98**, 125-130.

Singer, G., & Day, R. H. Spatial adaptation and aftereffect with optically transformed vision: Effects of active and passive responding and the relationship between test and exposure responses. *Journal of Experimental Psychology*, 1966, **71**, 725-731.

(Received for publication November 7, 1978;
accepted November 13, 1978.)