# Relation between adaptation to rearrangement and the source of motor-sensory feedback

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*The source of reafferent information during rearrangement determines the generality of adaptation. Walking with prism vision produces changes in sensorimotor coordinations entailing the limbs as well as the whole body, whereas viewing arm movements through prisms produces effects that are confined to eye-hand coordinations.*

Full and exact compensation of the errors in sensorimotor coordination, as well as the correction of several of the visuo-spatial distortions initially induced by rearrangement, is shown to be contingent upon self-produced movements during exposure with rearrangement; i.e. "active" prism exposure (Held & Hein, 1958; Held & Bossom, 1961; Held & Freedman, 1963; Mikaelian & Held, 1964).

There is evidence in the literature, however, which indicates that some types of self-produced movements during prism fail to generate adaptation. An interesting illustration of such failure is reported (Held & Hein, 1959) following the viewing, through wedge prisms, of translational arm movements confined to the midsagittal plane and guided over a groove to eliminate lateral movements; in the same condition lateral hand movements viewed through prisms produce significant adaptive shifts (a luminous spot on the hand, rather than the whole arm, seen through prisms). In another experiment Held & Mikaelian (1964) reported that compensatory changes of egocentric localization are generated when S, again viewing through wedge prisms, walks in a normally stimulating environment; no such changes occur when S propels himself seated in a wheelchair by manipulating the wheels with his arms. Despite the presence of self-produced movements in both exposure conditions (walking and arm movements) adaptation as measured by egocentric localization is evident only subsequent to walking.

What defines a particular set of self-produced movements as adequate for generating adaptation to the prism induced distortion? Adaptation is determined, generally, by measuring changes in the spatial guidance of the limb or body by sensory input following prolonged exposure to sensory distortion. Since in referring to adaptation it is necessary to specify the sensorimotor response used to measure it, the above question may be rephrased thus: Given a particular sensorimotor response to measure adaptation, what factors determine the adequency of self-produced movements during prism vision for generating systematic adaptive changes in that response?

To investigate this question, an experiment was designed in which adaptive changes in two categories of sensorimotor responses were explored following exposure with rearrangement entailing two different types of self-produced movement.

## Apparatus

A Held-Gottlieb (1958) type eye-hand coordination box with two vertically separated targets, and a vertical line setting apparatus which allowed S to adjust, through a control knob, the vertical orientation of a dimly luminous line in his frontal parallel plane in an otherwise dark room. Biteboards rigidly attached to both test apparatus reduced head movements during testing.

## Procedure

After preliminary (preexposure) measurements of monocular eye-hand coordination and adjustment of a line to vertical, each of eight subjects was exposed monocularly (right eye) to rearrangement with tilting prisms (20° counterclockwise). There were two exposure conditions: active gross exposure, walking in a normally lit hallway with the hands out of the visual field; and active eye-hand exposure, moving the hand in an arc in the frontal plane while viewing it through the tilting prisms (the only contours visible during eye-hand exposure were those of the moving arm). Postexposure measurements were taken at the end of 1/2 h exposure periods. The order of exposure and testing were permutated among the Ss.

## Results

The results are shown in Tables 1 and 2. The numbers refer to differences between pre- and postexposure readings. The reported changes of eye-hand coordination refer to the angle between the line connecting the centroids of the two sets of preexposure markings (two point target) and that connecting the centroids of the two sets of postexposure markings.

## Discussion

Table 1 indicates that gross active exposure to a tilted visual field generates compensatory changes in the adjustment of a line to the vertical, as well as cor-

Table 1.

Effects of ½ h of active gross exposure with 20° ccw tilting prisms

| Subject | Changes of eye-hand coordination | Changes of the perceived vertical |
|---|---|---|
| 1 | 4.0°cw | 5.8°ccw |
| 2 | 7.0°cw | 5.5°ccw |
| 3 | 1.0°cw | 10.6°ccw |
| 4 | 2.0°cw | 7.5°ccw |
| 5 | 2.5°cw | 3.6°ccw |
| 6 | 9.0°cw | 7.8°ccw |
| 7 | 6.5°cw | 4.4°ccw |
| 8 | 6.0°cw | 0.3°ccw |
| Means | 4.7°cw | 5.7°ccw |
| P (t-test) | 0.02 | 0.02 |

Table 2. Effects of ½ h of active eye-hand exposure with 20° ccw tilting prisms

| Subject | Changes of eye-hand coordination | Changes of the perceived vertical |
|---|---|---|
| 1 | 2.0°cw | 0.8°ccw |
| 2 | 2.5°cw | 0.7°ccw |
| 3 | 4.5°cw | 0.2°cw |
| 4 | 6.0°cw | 0.0° |
| 5 | 2.5°cw | 0.5°cw |
| 6 | 3.5°cw | 0.2°cw |
| 7 | 4.0°cw | 0.4°cw |
| 8 | 3.0°cw | 0.4°ccw |
| Means | 3.5°cw | 0.1°ccw |
| P (t test) | <0.01 | not sign |

*Note: The expected direction of changes of eye-hand coordination is clockwise (cw), that for the perceived vertical is counterclockwise (ccw).*

responding changes of eye-hand coordination. Table 2 indicates that active eye-hand exposure with tilting prisms succeeds in generating adaptive changes only in eye-hand coordination, failing to affect vertical adjustment. Hein & Held (1960), using wedge prisms and measuring egocentric localization and eye-hand coordination have reported similar findings. These results show that adaptation produced by walking with prism vision modifies sensorimotor responses entailing the coordinated action of the body as a whole, as well as those entailing the arms, while that produced by viewing arm movements through prisms is confined to limb responses; in other words, that adaptation produced by the former exposure condition generalizes, while the latter exposure condition produced only localized adaptation.

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