Comment on "Change in straight ahead during adaptation to prism"

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Recent research indicates that adaptation to prism-displaced vision² must be given an interpretation quite different from the one proposed by McLaughlin & Rifkin (1965). They concluded that the first stage of such adaptation consists of a change in the "apparent position" of a visual target, coupled with (or due to) a change in S's "entire egocentric frame of reference." This conclusion was reasonable, given their findings: after pointing several times at a target while seeing it and one hand through a sideways-displacing prism, Ss were able to point nearly accurately at a luminous line seen through the prism in a dark room—though they had pointed 7.7 cm to the right of the line before adapting. But surprisingly, when the Ss were asked to point "straight ahead" in a dark room, they pointed 5.4 cm to the left of where they had pointed before adapting.³

Both of these findings are corroborated by earlier studies in which Ss pointed at visual targets and "straight ahead" (Goldstein, 1964; Harris, 1963a; Pick, Hay & Pabst, 1963). In fact, if a biteboard keeps S from moving his head while adapting, the shift in pointing "straight ahead" is just as large as the shift in pointing at visual targets (Harris, 1963a).

Accordingly, these two shifts in behavioral response have recently been ascribed to a single underlying perceptual shift: a change in the felt position, relative to the rest of the body, of the arm that was seen through prisms (Hamilton, 1964a, 1964b; Harris, 1963a; Pick et al, 1963). When the adapted S feels that he is pointing straight ahead, he is actually pointing somewhat off to one side. Likewise, when he feels that he is pointing right at a sound-source, he is pointing to one side of it (Harris, 1963a; Pick et al, 1963).

If S sees only one hand through prisms, with head-movements excluded, there is little or no adaptation of the unexposed hand (Hamilton, 1964a; Harris, 1963a; and others). This rules out a change in "apparent position" of the seen target, since the adapted S points in different directions with his two hands, yet denies seeing the target in two places. Nor does such adaptation alter the "entire egocentric frame of reference," which determines S's judgments of "straight ahead." Ss who orient themselves so that a visual target looks straight ahead respond the same way after adapting as before (Hein & Held, 1960); so do Ss who verbally judge whether a sound sounds straight ahead (Harris, 1963b).

McLaughlin & Rifkin's description of adaptation as "a process in which a new pattern of voluntary behavior becomes associated with a specific visual impression"

is also misleading. Once the adaptation is established, it shows up even without any visual stimulus or voluntary movement:⁴ the blindfolded S verbally misjudges the distance between his two hands (Harris, 1963b) and when asked to point at his adapted hand with his unexposed hand (with which he points correctly at all other targets) he systematically misses (Efstathiou & Held, 1964; Harris, 1964; Goldstein, 1964), because he points to where he mistakenly feels his adapted hand is.⁵

If S moves his head while adapting⁶ he may undergo, in addition to the restricted adaptation discussed above, a more extensive kind of adaptation which does affect the perceived location of seen objects (Held & Bossom, 1961; Pick & Hay, 1964) and consequently affects pointing with either arm (Bossom, 1964; Bossom & Held, 1959; Cohen, 1963; Hamilton, 1964a). But these effects may also be due to altered position sense: a change in registered orientation of the head (Hamilton, 1964a, 1964b; Harris, 1963b; Mittelstaedt, 1964) or eyes (Helmholtz, 1962; Harris, 1963b). Such a change would not affect pointing "straight ahead" of the body.

Thus, McLaughlin & Rifkin's findings may be interpreted as follows: after adapting, S felt his hand to be 5.4 cm to the right of its actual location; this accounts for the observed shift in pointing "straight ahead," and about 5.4 cm of the shift in pointing at the line. The additional 2.2 cm shift in pointing at the line resulted from a change in registered orientation of the head or eyes relative to the rest of the body.

References

- BOSSOM, J. Mechanisms of prism adaptation in normal monkeys. *Psychon. Sci.*, 1964, 1, 377-378.
- BOSSOM, J., & HELD, R. Transfer of error-correction in adaptation to prisms. *Amer. Psychologist*, 1959, 14, 436. (Abstract)
- COHEN, H. B. Transfer and dissipation of aftereffects due to displacement of the visual field. *Amer. Psychologist*, 1963, 18, 411. (Abstract)
- CZERMAK, J. *Physiologische Studien. III. Sitzungsberichte der kaiserlichen Akademie der Wissenschaften (mathematisch-naturwissenschaftliche Classe)*, Vienna, 1855, 17, 563-600.
- EFSTATHIOU, AGLAIA, & HELD, R. Crossmodal transfer of adaptation to eye-hand rearrangement. Paper read at Eastern Psychological Association, Philadelphia, April, 1964.
- GOLDSTEIN, D. Unpublished experiments, McGill University, 1964.
- HAMILTON, C. R. Intermanual transfer of adaptation to prisms. *Amer. J. Psychol.*, 1964a, 77, 457-462.
- HAMILTON, C. R. Studies on adaptation to deflection of the visual field in split-brain monkeys and man. Unpublished doctoral dissertation, California Institute of Technology, 1964b.
- HARRIS, C. S. Adaptation to displaced vision: visual, motor, or proprioceptive change? *Science*, 1963a, 140, 812-813.
- HARRIS, C. S. Adaptation to displaced vision: a proprioceptive change. (Doctoral dissertation, Harvard Univ.) Ann Arbor, Mich.: University Microfilms, 1963b, No. 63-8162.

- HARRIS, C. S. Proprioceptive changes underlying adaptation to visual distortions. *Amer. Psychologist*, 1964, 19, 562. (Abstract)
- HEIN, A. V., & HELD, R. M. Transfer between visual-motor systems of adaptation to prismatic displacement of vision. Paper read at Eastern Psychological Association, New York, April, 1960.
- HELD, R., & BOSSOM, J. Neonatal deprivation and adult rearrangement: complementary techniques for analyzing plastic sensory-motor coordination. *J. comp. physiol. Psychol.*, 1961, 54, 33-37.
- HELMHOLTZ, H. von. *Treatise on physiological optics*. Translated from the 3rd German ed.; edited by J.P.C. Southall. Vol III. New York: Dover, 1962.
- McLAUGHLIN, S. C., & RIFKIN, K. I. Change in straight ahead during adaptation to prism. *Psychon. Sci.*, 1965, 2, 107-108.
- MITTELSTAEDT, H. The role of movement in the origin and maintenance of visual perception: discussion. In *Proc. XVII Int. Congr. Psychol.*, Amsterdam: North-Holland, 1964. P. 310. (Abstract)
- PICK, H. L., JR., & HAY, J. C. Adaptation to prismatic distortion. *Psychon. Sci.*, 1964, 1, 199-200.
- PICK, H. L., JR., HAY, J. C., & PABST, JOAN. Kinesthetic adaptation to visual distortion. Paper read at Midwestern Psychological Association, Chicago, May, 1963.

Notes

1. Preparation of this paper was supported by NIMH grant MH-10711-01.
2. Helmholtz, in 1866, was apparently the first to describe adaptation to prisms, despite a footnote in his book ascribing the experiment to Czermak (Helmholtz, 1962, p. 246). Actually, Czermak (1855, pp. 575-576) discussed only the inaccurate reaching that prisms cause at first; he did not mention the subsequent adaptation.
3. More precisely, McLaughlin & Rifkin's Ss moved a pointer along a track until they felt it was directly beneath the target or exactly straight ahead.
4. Active movement may, however, be essential for producing adaptation, as Held and others have proposed.
5. However, Efsthathiou & Held also reported that adaptation had no effect on blindfolded Ss' reaching for the remembered locations of targets touched previously. This finding is puzzling, since the task is so similar to pointing straight ahead.
6. Even the slight movements allowed by a chin rest (which McLaughlin & Rifkin used) may suffice (Harris, 1963b, p. 32).

Reply

Harris' interpretation is based on a dichotomy between the "restricted adaptation" which results from adapting with head immobile, in which changes in apparent position of the visual target are "ruled out," and in which the adaptive effect does not transfer from one hand to the other; and a "more extensive kind of

adaptation" which occurs when head movements are allowed during adaptation. Thus, in comparing his 1963 experiment with ours, he ignores the many differences in experimental procedure and implies that, had we but used a bite board, our results would have been the same as his.

A more reasonable basis for the interpretation of prism adaptation experiments is that control of head position is only one of many ways in which the conditions of adaptation and measurement can be varied to produce different adaptive effects. From this point of view, the most noteworthy feature of Harris' experiment is that each S made 234 pointing gestures in a single experimental session. (Our Ss, by contrast, made only a few side-to-side arm movements and had a minimum of kinesthetic experience.) It is not surprising that Harris found the adaptive effect manifested as a change in felt position of the hand; but one may disagree with his conclusion that all prism adaptation with head immobile is a matter of proprioceptive change.

A second assumption which underlies Harris' interpretation is more subtle. In his last sentence, he accounts for the greater change in "line" settings than in "straight ahead" settings by attributing the difference to "a change in the registered position of the head or eyes relative to the rest of the body," the implication being that such a change would affect "line" settings but would not alter S's judgment of "straight ahead." This is clearly an unwarranted assumption. Furthermore, the phrase "or the eyes" is misleading, for Harris elsewhere makes it clear that he attributes the difference between "line" and "straight ahead" settings to the "slight movements allowed by a chin rest" (note 5; see also his second paragraph).

Harris' criticism of our statements about "apparent position" of the visual target is well taken. We now suggest that the visual target will change in apparent position only when it shifts with respect to "straight ahead"—i.e., only during the second of the two adaptive processes which we described.

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