APA CENTENNIAL FEATURE

Comment on Asch and Witkin's "Studies in Space Orientation II."

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Asch and Witkin's (1948b) article was the second of four published by these authors during 1948 in the *Journal of Experimental Psychology*, all bearing the title "Studies in Space Orientation" but with different subtitles. It is, therefore, desirable to place the reprinted article in the context of the other three.

The first article (Asch & Witkin, 1948a) reported experiments with a tilted mirror, following up an earlier demonstration by Wertheimer (1912) and described by Koffka (1935, p. 215). The mirror was rotated about a horizontal axis so that the scene of a room was tilted in the third dimension, thus creating a conflict between the direction of the vertical and horizontal axes of the visual framework and the direction of gravity. The results were parallel to those reported in the reprinted article, in that many subjects fully accepted the mirrored scene as upright.

In the third article, Witkin and Asch (1948a) investigated the perception of the upright in a dark field, and thus in the absence of a visual framework. They found great accuracy when the observer was upright and certain systematic errors when the observer was tilted. However, despite the errors, constancy generally prevailed, in the sense that the vertical and horizontal directions were perceived despite the retinally tilted images of these orientations.

In the fourth article, Witkin and Asch (1948b) created a luminous rectangular perimeter that was tilted and within which a luminous rod could be adjusted until it appeared to be vertical or horizontal. Only these two objects were visible in the dark room. This is the method that was later adopted by many other investigators and came to be known as the *rod-and-frame effect*. The tilted frame exerted a substantial effect on the direction that appeared to be vertical, although the effect was not as great as those yielded by the tilted mirror or tilted room. Nonetheless, Witkin and Asch believed that this experiment demonstrated the effect of the visual framework to be autochthonous and not simply the result of knowledge about rooms.

The research reported in these four articles was cited by the American Psychological Association as one of the five "best experiments of 1948" (and the best to appear in the *Journal of Experimental Psychology* for that year; see Wolfle, 1949).

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What lessons about perception did these experiments provide, and how has their message fared over these 44 years? The experiments demonstrated the efficacy of a little-known gestalt principle of perceptual organization called the *frame of reference*. A definition of frame of reference (or framework) as implied by the Gestaltists and Asch and Witkin is as follows: a unit or organization of units that collectively serve to define a coordinate system with respect to which certain properties of objects, including the phenomenal self, are gauged. This concept was also invoked by Duncker (1929) to explain several phenomena of motion perception, particularly induced motion. A larger structure that is nearby or surrounds a smaller object tends to be taken as the frame of reference for the smaller object. Consequently, movement of the larger object (the framework) causes a smaller stationary object to be perceived as moving. A good example is the perception of the moon as gliding through the clouds when the clouds actually move slowly in front of the moon. For both orientation and motion, then, the frame of reference can be thought of as a *surrogate of the world*, in the sense that the frame stands for the upright or the stationary in a scene.

In the definition of the framework, I mentioned the phenomenal self as an object with perceived properties that are also affected by the framework. This refers to the fact that one's own body will appear upright or tilted depending on how it is oriented with respect to the frame of reference. Asch and Witkin showed this clearly in the reprinted article. Subjects frequently reported that they felt themselves tilted while viewing the tilted room when they perceived the tilted room as more-or-less upright. Similarly, if a framework surrounding a person is set in motion, it soon tends to be seen as stationary, and the motion of framework relative to self is interpreted as motion of one's body (Duncker, 1929; Dichgans & Brandt, 1974; Lishman & Lee, 1973; Rock & Smith, 1986). By regarding the body simply as another object in the field, the perceived tilt or motion of the self can be explained by the same lawful relationships to the reference frame as those that govern the perception of other objects. (For a more thorough analysis of the concept of frame of reference, the reader is referred to my recent article in a volume, appropriately enough, honoring Solomon Asch; see Rock, 1990.)

Another implications of the experiments in the reprinted article is the dominance of vision over proprioception, an early example of what later came to be called *visual capture*. Not mentioned in the reprinted article, however, is the fact that the research was motivated in part by earlier findings of

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Gibson and Mowrer (1938). They had claimed that conflicts between vision and proprioception concerning the upright were dominated by proprioceptive information about the direction of gravity and that gravity information was ontogenetically prior. In Asch and Witkin's experiments, however, despite veridical vestibular and other sensory information about the direction of gravity, the body not only appeared to be tilted when it was upright but also felt tilted. Analogously, in induced self motion (or *vection*, as it is now called), any sensory information that the body is stationary is dominated by the visual information of the frame of reference that it is moving. Subsequent research has shown that vision dominates and captures touch whenever a conflict is created, so that shape, size, and left–right hand movements are all misperceived when vision is distorted by optical devices (Hay, Pick, & Ikeda, 1965; Held, 1968; Rock & Harris, 1967; Rock & Victor, 1964). Interestingly, Gibson (1966) later came to emphasize what he called *visual* proprioception, the feedback or transformation of the whole optic array as a result of a person's movement in informing the person of where he or she was moving and at what velocity.

From a historical point of view, one might regard these experiments by Asch and Witkin as an early attempt to test the gestalt concepts using rigorous experimental methods. Where Wertheimer had demonstrated the righting of the (mirrored) scene by appealing to the introspective reports of observers' phenomenal experience, Asch and Witkin measured it by introducing a variable stimulus object, the rotatable rod, by running many naive subjects, each of whom received repeated trials, and by the application of statistical tests. This observation should not be interpreted as supporting the widely held, but false belief that the Gestaltists only offered demonstrations and did not perform formal experiments. Witness the countless experimental reports of the Gestalt psychologists in the journal *Psychologische Forschung* from 1922 to 1938. Today, there is widespread use of such methods to test gestalt ideas within the information-processing framework (e.g., Beck, 1982; Garner, 1981; Kubovy, 1981; Palmer, 1988; Pomerantz, 1981).

What has befallen the concept of frame of reference in general and, more specifically, with respect to the perception of the upright, since these articles appeared? Oddly enough, the thrust of research since then has been to suggest alternative explanations. Thus, for example, some investigators sought to reduce the effect of the frame to contrast, that is, to an overestimation of the angle between rod and frame (Gogel & Newton, 1975; Goodenough, Oltman, Sigman, Rosso, & Mertz, 1979). Others have suggested that the rod-and-frame effect results from induced ocular eye torsion (Goodenough et al., 1979; Hughes, 1973). Still others have claimed that the effect of the framework, particularly one of large angular subtense, is a direct neurophysiological outcome of stimulation of the peripheral retina (Ebenholtz, 1977, 1990; Ebenholtz & Callan, 1980). This theory is based on the claim that there are two modes of perception, and the one governing orientation is held to be based specifically on peripheral retinal stimulation (Held, 1970; Leibowitz & Post, 1982; Schneider, 1967; Trevarthen, 1968). However, recent work casts doubt on this claim (Warren & Kurtz, 1992) in demonstrating that perception of self-motion is not based on peripheral stimulation.

How might the explanation in terms of the frame of reference be tested against these alternative hypotheses? DiLorenzo and I (1982) reasoned that it is unfortunate that all these investigators have focused on the rod-and-frame paradigm, because the effect of the frame on the rod is modest in comparison with the almost complete effect of a tilted scene or room, such as Asch and Witkin demonstrate in the reprinted article. However, a frame large enough in visual angle to appear to surround the observer can also yield an almost complete righting. We recently demonstrated this fact by using a large frame and by introducing a method pioneered by Asch and Witkin, namely, requiring the subject to view the frame with head tilted (DiLorenzo & Rock, 1982). This apparently weakens the reliance on gravitational information. We regard this and other experiments reported by DiLorenzo and me as a vindication of the validity of Asch and Witkin's frame-of-reference explanation of their findings and a refutation of the various alternative explanations of them outlined earlier.

At the same time as the frame-of-reference explanation of orientation perception was being de-emphasized, the concept reemerged in explaining the perception of shape. In some of my work on the effect of orientation within a frontal plane on the perception of two-dimensional shape, I demonstrated that observers impose a Cartesian-like framework on an object, thereby assigning a top, bottom, and sides to it. That assignment has a profound effect on phenomenal shape (Rock, 1973).

Thus far I have not mentioned the individual differences in setting of the rod to the vertical. In all the experiments on the effect of a tilted room or frame, there were some subjects who totally accepted the tilted frame as upright and others who seemed to resist the frame and selected an orientation as vertical that was closer to the direction of gravity. These tendencies later came to be referred to as *field dependent* and *field independent*, respectively. Witkin was particularly interested in these differences, so at this point he and Asch parted company. Together with psychometricians and clinical psychologists, Witkin sought to correlate these differences with differences in other perceptual tasks (e.g., the embedded figure test), and with sex, intelligence, and personality (Witkin et al., 1954, 1962). This work was among the first investigations of what came to be called *cognitive styles* (see Witkin & Goodenough, 1981).

The concept of frame of reference is still very much alive and kicking, as attested to by the fact that Stephen Palmer and I are investigating it at this very moment. There is both conceptual confusion and empirical contradiction with respect to the concept. For example, it can hardly be true that the frame perimeter used in the typical rod-and-frame experiment is a surrogate for the upright world if it is seen to be tilted, which it is. Also, if a frame smaller than the one in the Asch and Witkin experiment is used, say 10° square in angular subtense, an error of only about 1° is obtained in judgments of the vertical—a far cry from the effect described in Asch and Witkin's reprinted article. So, we have concluded that there are two kinds of reference frame. One is indeed a world surrogate. It appears upright when tilted or stationary when

moving. To qualify as a world surrogate a frame must either be large or surround the subject, or both. It has the capability of affecting the perception of the self. The other kind of frame, which we call a *hierarchical frame*, is not a world surrogate and in fact is perceived veridically as tilted or moving. It is most effective when the objects surrounding the frame appear to belong to it, an appearance that is facilitated in turn by similarities in size, depth, color, and the like. The properties of objects governed by a hierarchical frame tend to be perceived in relation to it, whereas the properties of the frame itself tend to be perceived in relation to whatever frame surrounds the hierarchical frame. An example of this hierarchical organization is that of a person waving goodbye while standing on the steps of a moving train. The moving hand appears to be moving only vertically although in fact its path through space is sinusoidal (because of the forward motion of the train). So the train is the reference for the waving hand and yet the train's motion is perceived vertically.

In any event, we see that Asch and Witkin called attention to the previously neglected gestalt principle of the frame of reference and investigated its effects using quantitative techniques. In this commentary, I have noted the implications of this important concept for the perception of orientation, motion, shape, and the self, for visual capture, and for individual differences.

References

Asch, S. E., & Witkin, H. A. (1948a). Studies in space orientation: I. Perception of the upright with displaced visual fields. *Journal of Experimental Psychology, 38,* 325–327.

Asch, S. E., & Witkin, H. A. (1948b). Studies in space orientation: II. Perception of the upright with displaced visual fields and with body tilted. *Journal of Experimental Psychology, 38,* 455–477.

Beck, I. (1982). Textual segmentation. In J. Beck (Ed.), *Organization and representation in perception* (pp. 285–317). Hillsdale, NJ: Erlbaum.

Dichgans, J., & Brandt, T. (1974). The psychophysics of visually induced perception of self-motion and tilt. In F. O. Schmidt & F. G. Worden (Eds.), *The neurosciences* (Vol. 3, pp. 123–129). Cambridge, MA: MIT Press.

DiLorenzo, J., & Rock, I. (1982). The rod and frame effect as a function of righting of the frame. *Journal of Experimental Psychology: Human Perception and Performance, 8,* 536–546.

Duncker, K. (1929). Über induzierte Bewegung [On induced motion]. *Psychologische Forschung, 12,* 180–259.

Ebenholtz, S. M. (1977). Determinants of the rod and frame effect: The role of retinal size. *Perception & Psychophysics, 22,* 531–538.

Ebenholtz, S. M. (1990). Metamorphosis from rod and frame to visual-vestibular interaction. In I. Rock (Ed.), *The legacy of Solomon Asch* (pp. 233–242). Hillsdale, NJ: Erlbaum.

Ebenholtz, S. M., & Callan, J. W. (1980). Modulation of the rod and frame effect: Retinal angle vs. apparent size. *Psychological Research, 42,* 327–334.

Garner, W. R. (1981). The analysis of unanalyzed perceptions. In M. Kubovy & J. R. Pomerantz (Eds.), *Perceptual organization* (pp. 119–139). Hillsdale, NJ: Erlbaum.

Gibson, J. J. (1966). *The senses considered as perceptual systems.* Boston: Houghton-Mifflin.

Gibson, J. J., & Mowrer, O. H. (1938). Determinants of the perceived vertical and horizontal. *Psychological Review, 45,* 300–323.

Gogel, W. C., & Newton, R. E. (1975). Depth adjacency and the rod and frame illusion. *Perception & Psychophysics, 18,* 163–171.

Goodenough, D. R., Oltman, P. K., Sigman, E., Rosso, J., & Mertz, H. (1979). Orientation contrast effects in the rod and frame test. *Perception & Psychophysics, 25,* 419–424.

Hay, J. C., Pick, H. L., & Ikeda, K. (1965). Visual capture produced by prism spectacles. *Psychonomic Science, 2,* 215–216.

Held, R. (1968). Dissociation of visual functions by deprivation and rearrangement. *Psychologische Forschung, 31,* 338–348.

Held, R. (1970). Two modes of processing spatially distributed visual stimulation. In F. O. Schmidt (Ed.), *The neurosciences: Second study program* (pp. 317–324). New York: Rockefeller University Press.

Hughes, P. C. (1973). The influence of the visual field upon the visual vertical in relation to ocular torsion of the eye. Doctoral dissertation, University of Oklahoma. *Dissertation Abstracts International, 33,* 468B. (University Microfilms No. 73-91, 58B)

Kofka, K. (1935). *Principles of gestalt psychology* (p. 215). New York: Harcourt, Brace.

Kubovy, M. (1981). Concurrent-pitch segregation and the theory of indispensable attributes. In M. Kubovy & J. R. Pomerantz (Eds.), *Perceptual organization* (pp. 55–98). Hillsdale, NJ: Erlbaum.

Leibowitz, H. W., & Post, R. B. (1982). The two modes of processing concept and some implications. In J. J. Beck (Ed.), *Organization and representation in perception* (pp. 343–363). Hillsdale, NJ: Erlbaum.

Lishman, J. R., & Lee, D. N. (1973). The autonomy of visual kinesthesis. *Perception, 2,* 287–294.

Palmer, S. E. (1988). Reference frames in the perception of shape and orientation. In B. Shepp & S. Ballesteros (Eds.), *Object perception: Structure and process* (pp. 121–163). Hillsdale, NJ: Erlbaum.

Pomerantz, J. R. (1981). Perceptual organization in information processing. In M. Kubovy & J. R. Pomerantz (Eds.), *Perceptual organization* (pp. 141–180). Hillsdale, NJ: Erlbaum.

Rock, I. (1973). *Orientation and form.* San Diego, CA: Academic Press.

Rock, I. (1990). The frame of reference. In I. Rock (Ed.), *The legacy of Solomon Asch* (pp. 243–268). Hillsdale, NJ: Erlbaum.

Rock, I., & Harris, C. S. (1967). Vision and touch. *Scientific American, 216,* 96–104.

Rock, I., & Smith, D. (1986). The optomotor response and induced motion of the self. *Perception, 15,* 497–502.

Rock, I., & Victor, J. (1964). Vision and touch: An experimentally created conflict between the senses. *Sciences, 143,* 594–596.

Schneider, G. E. (1969). Two visual systems. *Science, 163,* 895–902.

Trevarthen, C. (1968). Two mechanisms of vision in primates. *Psychologische Forschung, 31,* 52–62.

Warren, W. H., & Kurtz, K. J. (1992). The role of the central and peripheral vision in perceiving direction of self-motion. *Perception & Psychophysics, 51,* 443–454.

Wertheimer, M. (1912). Experimentelle studien über das Sehen von Bewegung [Experimental studies of vision and motion]. *Zeitschift fur Psychologie, 61,* 161–265.

Witkin, H. A., & Asch, S. E. (1948a). Studies in space orientation: III. Perception of the upright in the absence of a visual field. *Journal of Experimental Psychology, 38,* 603–614.

Witkin, H. A., & Asch, S. E. (1948b). Studies in space orientation: IV. Further experiments on perception of the upright with displaced visual fields. *Journal of Experimental Psychology, 38,* 762–782.

Witkin, H. A., Dyk, R. B., Faterson, H. F., Goodenough, D. R., & Karp, S. A. (1962). *Psychological differentiation.* New York: Wiley.

Witkin, H. A., & Goodenough, D. R. (1981). *Cognitive styles: Essence and origins.* Madison, CT: International Universities Press.

Witkin, H. A., Lewis, H. B., Hertzman, M., Machover, K., Meissner, P. B., & Wapner, S. (1954). *Personality through perception.* New York: Harper.

Wolfle, D. (1949). Across the secretary's desk: The best psychological paper of 1948. *American Psychologist, 4,* 508–509.