

INTERACTION OF DETERMINANTS OF PERCEIVED MOVEMENT DIRECTION

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Summary.—Determinants of apparent movement direction were systematically combined. The stimulus situation used was one which ordinarily produces a tendency to see movement from two sides to the center. This tendency can be modified to produce movement to the left or right. The determinants used in the study were (1) fixation to one side of the stimulus; (2) movement connotations in the stimulus figures (meaning); and (3) identity (vs dissimilarity) of stimulus figures. Fixation was paired with meaning (a weak determinant) and with identity (a strong determinant). In these pairs, the variables were combined (a) "reinforcing" each other and (b) "opposing" each other. The results did not conform to a simple summation model, but rather showed that each set of determinants acts in unique combination. The effectiveness of any given determinant in the perceptual process depends in part on the other determinants operating in the situation.

The study reported here combined three methods for influencing the perceived direction of apparent movement. It used these methods (1) in opposition to each other, (2) in additive fashion, and (3) in isolation. The object of the study was to explore the question: do determinants of movement perception exercise their effects by adding to and subtracting from each other, or do they act as unique combinations?

EXPERIMENTAL ARRANGEMENTS

Simple stroboscopic movement does not readily lend itself to directional modification. The movement may look "good" or "bad," it may be "complete" or "partial," and it may appear "pure" or in the form of a "moving object." But the direction of the movement remains invariant, from the first flash to the second flash (except for delta movements, in which the second stimulus is disproportionately bright).

In order to obtain a condition in which movement direction is more susceptible to modification, three lights are necessary. This type of presentation was used and described by von Schiller (1933). Von Schiller showed that, if a light is preceded or followed by two others (presented simultaneously on either side of it), a bilateral movement will occur. This movement will take place equally and impartially in both directions, in line with what von Schiller called the "tendency toward total assimilation." This tendency operates most strongly when the stimulus configuration is symmetrical (that is, when the second set

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of stimuli is equidistant from the first, and the lights are of the same brightness, color, and shape). If the configuration is made sufficiently asymmetrical (if the stimuli on one side are different from those on the other) movement may occur predominantly toward one side. For instance, if a light is followed by another light relatively close to it on the right, and one further away on the left, the movement might be seen predominantly or exclusively to the right.

In the experiments detailed here, three lights were used in horizontal sequence. The two "outside" lights were presented first (simultaneously) and the center light flashed second. Such a presentation usually is perceived as *two lights moving toward a point between them*. A successful effort to determine directionality is one in which movement occurs exclusively or predominantly *from one side to the center*.

The Variables

One of the variables used in the present study is *fixation*. In his monograph on apparent movement, Wertheimer (1925) reports that fixation facilitates the perception of movement. Other investigators have made similar observations (Van der Waals & Roeloffs, 1930). Von Schiller (1933) experimented with fixation to one side of composite movement presentations, and found that fixation favored movement to the fixated side. Fixation is used in the present study in line with von Schiller's use of this determinant.

Another determinant mentioned by von Schiller is *identity* (as against dissimilarity) of stimulus figures. Paul Linke (1907) conceived of "identity" as the basic condition for movement. Other investigators have stressed the fact that movement occurs most easily when the two stimulus figures are perceived to be the same (Stern, 1894; Neff, 1936). Von Schiller found that movement will tend to assimilate to the most similar figure, if other factors are constant. This observation forms the basis of the second variable used in the present study.

Since "identity" is a very potent determinant of movement direction, a relatively weak determinant seemed necessary for the sake of contrast. Such a determinant is provided by the use of *meaning connotations* in the stimulus figure. A number of investigators (Blug, 1932; Comalli, Werner, & Wapner, 1957; DeSilva, 1926; Fuchs, 1928; Krolik, 1929; Toch, 1962) have found that "meaningful" stimulus figures used in non-optimal or ambiguous movement conditions can affect the direction of perceived movement. Krolik (1929) convincingly demonstrated, for instance, that when a "stationary" object (e.g., a house) is paired with a "movable" object (like an automobile) in an induced movement situation, the "movable" object will tend to monopolize the movement. In a small demonstrative experiment, Toch and Ittelson (1956) showed that meaningful stimuli (bombs, airplanes) can determine unidirectionality in von Schiller's condition. This was further demonstrated by Krampen and Toch

(1960) who used arrows and arrow-like designs as stimulus figures. The effects of meaning connotation in determining movement are definite but circumscribed. They are obtained with *most* Ss under *some* conditions and with *some* Ss under *most* (non-optimal) conditions. This stands in contrast to the effects of identity, which are generally unambiguously present.

The design of the present study capitalizes on this difference by independently pairing (1a) identity and (1b) meaning connotation with (2) fixation. Thus, the same common determinant (fixation) is paired with a relatively weak condition (meaning) and a relatively strong one (identity). The interaction product of these two pairs of determinants will be compared.

Apparatus

The apparatus used was identical with the one used by Krampen and Toch (1960) and similar to that used by Toch and Ittelson (1956). It permitted successive presentation of pictorial material on adjacent areas of a silvered glass screen. The exposures and intervals were timed by means of interval timers wired in series. Brightness was controlled with a variable transformer, set by means of a voltmeter.

The viewing unit of the apparatus comprised three light-proof compartments fronted with diffusion glass. Each compartment was 4.5 in. high and 2.5 in. wide and contained two 7.5-w filament bulbs. Between the diffusion glass fronting the compartments and the screen of silvered glass, photographic transparencies could be inserted with a slideholder, which centered a stimulus object over each compartment.

In the present study, the timing was adapted from von Schiller (1933). Flash durations were maintained at 500 msec.; the interval between flashes was 15 msec. Brightness was approximately 11 ft.-candles.

A 7.5-w red bulb was used as a fixation object. It was placed about 2 in. to one side of the viewing screen. The screen itself was located 7 ft. directly in front of the observer. All observations were binocular, with the observer's head placed in a headrest. The observations were made in the dark.

Stimulus Material

Each of the stimulus slides contained three transparent figures on opaque ground. The figures were approximately $\frac{3}{4}$ in. long, at a distance of $2\frac{1}{2}$ in. from each other. Three types of slides were used.

(1) *Control slides*.—This set of three slides featured objects which would not be presumed to have a directional connotation. One slide featured three symmetrical geometrical figures (ovals); the second contained presumably "immobile" objects (trees); the third consisted of "mobile" but symmetrical objects (sailing boat).

(2) *Weak (meaningful) slides*.—These three slides each featured three identical objects which were presumed to have a meaningful movement direction.

The slides in question were (1) a slide featuring three arrows, (2) one containing three speedboats, and (3) one with three "jumping" deer. In each case, the objects were "aimed" in the same direction.

(3) *Strong (non-identical) slides.*—In the case of these slides, the center object was identical to the object on one side of it, but different from the object on the other side. The data reported here were obtained with the following five slides: (1) two "standing men" and an upright oval; (2) two "running men" and a tree; (3) two ovals and an arrow; (4) two human figures and a ship; (5) two "running men" and a "standing man."²

Procedure

One hundred and fifty-three observers were employed. Sixty-four Ss observed the three slides with meaning connotation (weak directional connotation); 57 Ss observed the five strong (identity) slides. Thirty-two observers comprised the control group, which viewed the three slides with no directional connotation.

The slides were always presented in the same order. Each S observed one set, under (1) no fixation (free observation); (2) fixation to one side of the screen, and (3) fixation to the other side. Observations without fixation always preceded observations under fixation. Half the Ss in each group fixated first to the right of the screen, and the other half started by fixating to the left. Thus, when viewing a stimulus whose meaning suggested movement to the right, an equal number of observers started by fixating to the right (thus reinforcing the predominant direction) and to the left (presumably neutralizing the preferred direction).

Each observer was told, "this is an experiment to investigate the conditions for seeing movement; movement like in the movies or neon signs that seem to move. I want you to watch this screen and tell me what you see." S was permitted as many observations as he felt necessary to form his percept. In the case of observations under fixation, Ss were asked to "concentrate" on the fixation light, and to make observations "out of the corner of your eye."

RESULTS

Tables 1, 2 and 3 summarize the results. Table 1 shows the effects of combining fixation with movement connotation of the stimulus figures. The first line of the table confirms that the effects of meaning in our situation are weak. Seven out of 10 free observations yielded perceptions of movement to the center. Only 15% of observations brought perceptions of movement toward one side, usually in the "meaningful" direction.

²The figures in four of the slides are "meaningful" in addition to being dissimilar. The initial object was to maximize the determining effect of stimulus configuration by combining identity and meaning. This, however, did not prove possible, since no differences could be obtained between the perception of "meaningful" and "geometrical" versions of these slides. The only relevant determinant of movement seemed to be identity.

TABLE 1
 INTERACTION EFFECT OF FIXATION AND CONNOTATION OF STIMULUS FIGURES, IN
 DETERMINING MOVEMENT DIRECTION ($N = 64$); PROPORTION OF
 OBSERVATIONS ($N = 192$)

Conditions	None	Movement		
		Toward Center	In Meaningful Direction	In Opposed Direction
No Fixation	15.6%	69.8%	12.5%	2.1%
Fixation Opposed to Meaning	8.3	44.8	16.1	30.8
Fixation Reinforcing Meaning	5.7	40.4	44.1	9.8

Succession (no movement) was more frequently reported when the slides were freely viewed than when one side was fixated.³ Fixation also strikingly reduced the prevalence of movement from both sides toward the center. Unilateral movement occurred more frequently under fixation, with a strong tendency for the movement to proceed in the *fixated* direction. The combined effect of fixation and meaning yielded 44% movement in the fixated-and-meaningful direction; when fixation "opposed" meaning, the movement occurred twice as frequently in the fixated than in the "meaningful" direction. Fixation appeared to increase movement in the fixated direction by about 30%, and to occasion a slight increase in movement in the opposing direction.

Table 2 shows the results of combining fixation with identity. Identity determined movement direction in 4 out of 10 free observations. Fixation did not greatly enhance or reduce this proportion. The most marked effect of fixation was to enhance the proportion of movement perceived in the "dissimilar" direction when fixation "opposed" identity. Whereas movement in the "identical" direction diminished by only 4% from the corresponding observations under free viewing, movement to the fixated-but-dissimilar side was enhanced by over 12%. When the side containing the identical figures was fixated, the proportion of "correct" movements increased very slightly (some 4%).

Fixation again brought a decrease in the proportion of "no movement" responses,⁴ but movement toward the center was observed in the same proportion (4 out of 10) of fixation and non-fixation trials.

Table 3 summarizes the data obtained from the control group, demonstrating the effects of fixation alone. There appear to be three salient effects: (1) the proportion of "no movement" responses decreases with fixation,⁴ (2) the proportion of percepts of symmetrical movement toward the center decreases, and (3) the proportion of unilateral movements increases. There is

³The decrease in "no movement" responses from "no fixation" to "fixation" trials is not attributable to practice; the proportion of such responses does not systematically change over time in the fixation trials.

⁴See Footnote 3.

TABLE 2
 INTERACTION EFFECTS OF FIXATION AND IDENTITY OF STIMULUS FIGURES, IN
 DETERMINING MOVEMENT DIRECTION ($N = 57$); PROPORTION OF
 OBSERVATIONS ($N = 285$)

Conditions	None	Movement		
		Toward Center	In Direction of Identical Figure	In Direction of Dissimilar Figure
No Fixation	14%	40.2%	38.5%	7.3%
Fixation Opposed to Identity	6.9	39.2	34.0	19.8
Fixation Reinforcing Identity	6.0	42.1	42.8	9.1

a *tendency* for the movement to occur in the fixated direction, but fixation also appears to enhance movement in the opposite direction.

If we compare the results of our three conditions, we find that fixation or dissimilarity of the figures reduced the tendency toward total assimilation (movement to the center). *Least* movement of any kind was observed when stimuli without meaning connotation were freely viewed. *Most* movement was observed with combinations of determinants, almost irrespective of the nature of the combination. Our common determinant, fixation, clearly entered into different situations in different fashion. The nature of this process merits a word of discussion.

TABLE 3
 EFFECT OF FIXATION ALONE IN DETERMINING MOVEMENT DIRECTION ($N = 32$);
 PROPORTIONS OF OBSERVATIONS

Conditions	No.	None	Movement			
			Toward Center	To Fixated Side	To Non- fixated Side	Total to Side
No Fixation	96	27.8%	66.0%			6.2%
Fixation to One Side	192	10.9%	47.4%	25.6%	16.1%	41.7%

DISCUSSION

We combined the determinants of movement direction in an effort to ascertain the effects of such combinations. When the stimulus was presented in the absence of these determinants, it was perceived to move by 3 out of 4 observers, and in almost every such case the movement was seen to occur from both sides to the center. This is the type of movement von Schiller (1933) described as obeying the "tendency toward total assimilation." The assigned role of our determinants was to offset the tendency toward total assimilation and to channel the movement to the left or to the right.

One of the determinants employed was *fixation*. When used alone, fixation increased the perception of movement in general and brought about some

unilateral movement, with more movement occurring to the fixated side than to the opposite side. A second determinant used was *meaning*, or meaning connotations in the stimulus figure. Although meaning did not prove sufficiently powerful to reduce the tendency toward total assimilation,⁶ it did produce movement in the "meaningful" direction in 1 out of 10 observations. By contrast, the third determinant employed, *identity*, produced a sizable increase in movement toward one side, between the identical (as opposed to dissimilar) figures.

When *fixation was combined with meaning*, the combination at one point almost acted like a summation. When meaning was "reinforced" by fixation, it produced movement in the meaningful-and-fixated direction only slightly in excess of what would be expected by adding the two isolated effects. When meaning was "opposed" by fixation, the movement in the fixated-but-meaningless direction was somewhat in excess of the effect of fixation on a neutral figure.

On the other hand, the non-fixated sides of the perceived stimuli behaved in a rather surprising fashion, if one predicts from a simple summation model. Table 3 shows that a neutral figure under fixation moved to the non-fixated side in 16% of the observations. It seems to follow that when a meaningful figure is fixated, and meaning connotations exercise some effect in isolation, we should expect a corresponding increase in the non-fixated-but-meaningful direction beyond the effects of meaning or fixation alone. And yet, the proportion of observations yielding movement in the non-fixated direction with a meaningful stimulus is the same as that produced by fixating a neutral figure. Moreover, *subtraction* seems to occur in the non-fixated-non-meaningful cell of the reinforcing condition. It appears, in the latter case, as if the fixation of meaningful direction (expected movement direction of a meaningful figure) can maximize the effect of meaning beyond what we would expect from the somewhat non-directional effects of fixation *per se*. This provides support for the assumption that anticipatory fixation of a meaningful direction of movement may exercise a facilitating effect on movement perception in real life.

When *fixation was combined with identity*, nothing remotely like summation occurred. Fixation was apparently able to exercise only a slight effect on the product of these interactions. When identity and fixation "opposed" each other, fixation did enhance movement in the direction of dissimilarity, but it slightly reduced (rather than enhancing) the movement between identical figures. When fixation "reinforced" identity, it exercised almost no effect at all, except for facilitating the perception of movement in general. Identity as a determinant seemed to account for most of the perceptual product in all these cases.

⁶The role of meaning is not necessarily as insignificant as these results might suggest. More directive instructions, for instance, increase the proportion of movement perceived in the "meaningful" direction.

It is interesting to note that the proportions of movement seen to the dominant side in our two conditions are analogous. These proportions were almost the same when fixation reinforced meaning as when fixation was added to identity. Obviously, however, variables entered differently into the determination of these equivalent products.

These types of results show that not only can the same perceptual result be arrived at in different ways, but that perceptual determinants can have varying degrees of effectiveness, depending on the combination of determinants within which they occur. In our case, when fixation was combined with meaning, it exercised a powerful effect on the perceived direction of movement; when combined with identity, its effects were almost imperceptible. The determinant which in one situation may be crucial, in another may be trivial; the "vital" cue in one context may become completely submerged in another. The role of any given variable in the perceptual process is at least in part conditioned by the richness or poverty of the stimulus situation to which it is uniquely linked. Can the relative potency of perceptual determinants be predicted? Further work might tell.

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