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Cue Conflict and Apparent Visual Movement

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CUE CONFLICT AND
APPARENT VISUAL MOVEMENT

by

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INTRODUCTION

The perception of apparent visual motion has long been within the purview of psychological investigation (Roget, 1825). One of the most investigated forms of apparent motion has been the phi phenomenon, the simplest form of stroboscopic motion. The term, phi phenomenon, refers to the perception of motion induced by the rapid sequential flashing of spatially distinct light sources.

Although Exner (1875) accidentally produced apparent motion by rapidly presenting two sparks, Wertheimer (1912) was the first to investigate and name the phi phenomenon. Wertheimer (1912) experimentally manipulated the pause interval between the sequential flashing of two lights to achieve what he called optimal movement. Kenkel (1913) described three additional forms of apparent motion using the same type of apparatus: alpha, beta, and gamma movement. Alpha movement involved the apparent change of size of an object under successive presentations. Gamma movement denoted the apparent swelling up or contraction of an object under successive presentations. Beta movement, the most frequently investigated and the object of attention in this study, refers to the apparent motion of an object from one place to another. Beta movement is now sometimes referred to by the phrase optimal movement (Boring, 1942).

Besides the length of the pause interval, several other factors have been found to affect phi and/or beta movement. These factors include duration of stimulus exposure, distance between stimuli, form, relative differences in intensity, wavelength distributions, and conditions of the subject (Graham, 1951). The literature on these factors has also been reviewed by Hovland (1935), Fernberger (1941), and Aarons (1964).

DeSilva (1926) was the first experimenter to report a study in which meaningful figures were used in a phi phenomenon type of presentation. He found that meaningful objects move more readily, i.e. have lower thresholds, than simple lines: The arm of a sketched man will move up to his forehead in a salute more readily than one line will rotate toward another through the same angle. His conclusions that movement connotations affect the threshold and direction of apparent motion were confirmed by Blug (1932). Both these studies have been criticized by Epstein (1967) for having few Ss and lacking attention to structural factors which favor apparent motion.

Jones and Bruner (1954) reexamined the role of motion connotative factors. They used the stick figure and alternated it with a nonsense figure placed equidistant but in the opposite direction. S was asked to report the relative speed and distance of movement of the two objects. After only one trial, 85% of the Ss reported that the man appeared to move faster and farther. The effect disappeared by the fifth trial. In the same paper, Jones and Bruner reported another experiment in which two directions were possible. The situation presented to S had been described by Ternus (1938). Three successive presentations of two each of four lights are arranged in the order: (1) 0 0, (2) 00 , (3) 0 0. Jones and Bruner (1954) predicted that S would see either an exchange of place of two objects or a collision and bouncing off of two objects depending on his individual experiential history. They found that ten of fifteen baseball players saw a crossover, while eleven of fifteen billiard players saw the bounce.

Krampen and Toch (1960) examined the role of directional determinants and used for their study arrows and arrow-like figures. Thsy asked "How much like an arrow does an arrow have to look before its 'arrowness' becomes an effective determinant of perceived movement direction?" (Krampen and Toch, 1960, p. 273). They used a three light presentation, in which the illumination of the center figure followed the simultaneous presentation of the two outer lights. They were able to confirm their hypothesis that the more an arrow-like figure looks like an arrow, the greater will the effect of motion connotation be. Toch (1963) conducted a further study in which other determinants were examined. Fixation to one side of the stimulus, movement connotations of the stimulus figure, and identity (vs dissimilarity) of stimulus figures were utilized in opposition to each other, in additive fashion, and in isolation. He concluded that fixation, when combined with meaning, i.e., with stimulus figures having motion connotations, exercized a powerful effect on the perceived direction of motion, but when combined with identity, had little or no effect. Thus the same perceptual determinants can have varying degrees of effectiveness, depending on how they are combined or controlled.

Kelly (1935) demonstrated that past experience and suggestion affect the perception of apparent motion. Of 400 naive Ss, approximately half reported seeing simple movement (two lights flashing) without any suggestion. When movement was suggested, 94% of the group reported seeing movement. Of the 48% reporting a difference in the upward and downward speed of vertical movement, 32% reported a more rapid falling motion, and 16% a more rapid rising motion.

Lyngen (1967) conducted a study to determine the effects of past experience on the speed with which figures were seen to move. In addition to four simple geometric figures, he used figures of a stick man, jet airplane, and sailboat, and found that Ss perceived the stimulus figures as moving at significantly different speeds although they were all presented in the same temporal sequence. The direction of the differences was the same as was suggested by a rank ordering of the stimulus objects by an independent group, and these ranks were highly correlated with a similar rank order by the actual Ss. One interesting feature of Lyngen's study was his response measure. He was able to quantify the perceived speed of each stimulus figure by having each S match the horizontal speed of the blip on an oscilloscope to the speed at which the figure appeared to move.

Lyngen's results are predictable from a study by Biel (1948) who demonstrated that different types of aircraft were perceived as moving at different speeds depending on the observers' familiarity with the performance characteristics of the aircraft. Although Biel's study involved actual flying aircraft, his method is comparable to Lyngen's, as demonstrated by Morinaga, Noguchi, and Yokoi (1966) who found no difference between judgements of real and apparent motion.

At one point in his study, Lyngen altered the orientation of two of his stimulus figures (stick man and arrow) and obtained results different than those he obtained with the figures in their normal orientation.

The present study was conducted to determine the effects of conflicting cues, unusual orientations of the stimulus figures, on the perceived speed of objects with which the Ss had previous experience, i.e., objects having motion connotations. The hypothesis was that different orientations would produce different amounts or degrees of enhancement or inhibition of the effect of motion connotations on the perceived speed of the stimulus figures.

METHOD

Subjects

One hundred fifty (150) students enrolled at Western Michigan University served as Ss.

Apparatus

The stimulus figures were a jet plane, a propellor driven plane, a stick man, a stick woman, a simple sailboat, and a fully rigged sloop. The jet plane, stick man, and sailboat were replicas of the stimulus figures used by Lyngen (1967). All figures were cut from heavy black opaque construction paper, with the resultant 'stencil' used for presentation, so that the stimulus figure appeared as a white object in a dark surround. Length and height of the stimulus figures were varied in an effort to roughly equalize total area (Fig. 1).

The stimulus figures were mounted on the ends of cylindrical canisters supplied as component parts of a phi phenomenon presentation device manufactured by Psychological Instruments, Inc. One of the four canisters was eliminated, and the remaining three canisters were placed horizontally. The front surface of each canister was made of translucent plastic, and measured 2½" in diameter. Each canister contained a light, the flashing, duration, and intensity of the lights being controlled from a separate panel. The three canisters were placed equidistant from one another such that the total distance from the outside edges of the first and third canisters was 12". The centers of all canister faces were 8½" from the surface of the table on which the apparatus was mounted. The duration of each flash was set at 100 msec with 60 msec delay between flashes. Recycling time, from the disappearance of the third flash to the reappearance of the first, was 220 msec. Flash sequence was from left to right,

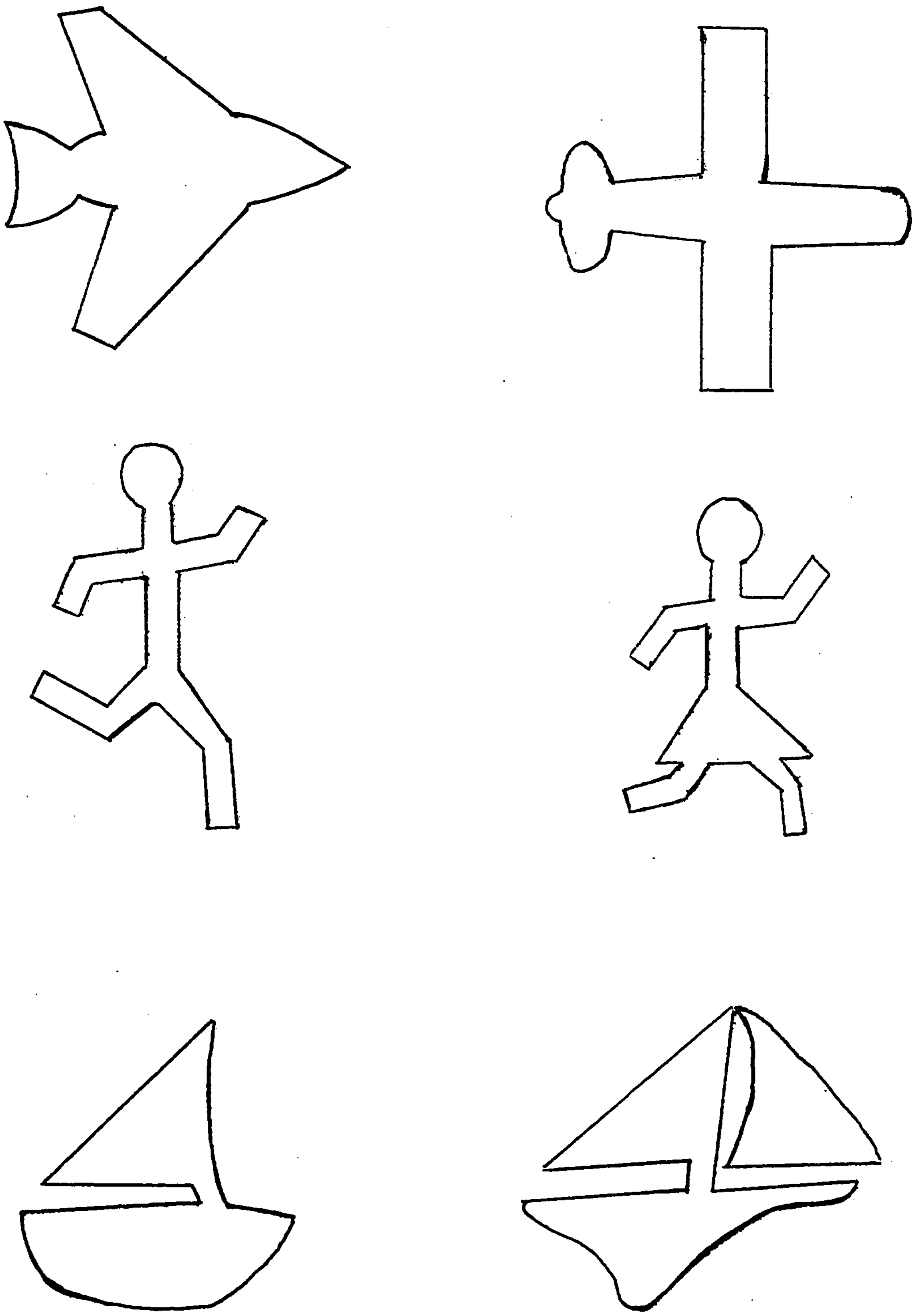

Fig. 1 Stimulus figures

abc.

The response measure incorporated an RCA WO-56A 6" oscilloscope which was modified by the insertion of a variable impedance device allowing S to remotely adjust horizontal sweep speed. The control was movable, and was placed before S's preferred hand. S adjusted the control by means of a fluted knob, to which was attached a circular scale. The oscilloscope was positioned on S's left and the phi apparatus on the right such that the inside edges of both units were tangent to the direct line of sight of S, whose head was held in a stable orientation and position by a chin cup. Both the screen of the oscilloscope and the front, illuminated faces of the three light canisters were placed perpendicular to S's line of sight. The oscilloscope was placed at a distance of 72" from S, in order to equate the 12" width of stimulus object travel to the 6" width of blip travel on the oscilloscope screen (Fig. 2).

Procedure

To avoid possible interactions between stimulus objects and/or orientations within Ss, as well as to preclude satiation and the subsequent deterioration or disappearance of the phi effect, thirty random groups were used. Each group was presented only one orientation of one stimulus object. Orientations used were: normal, rotated 90° clockwise, reversed, tumbling forward, and tumbling backward. The effect of tumbling was achieved by rotating adjacent stimulus objects by 120° (Fig. 3).

Each S was assigned randomly to one of the thirty groups. In a typical session, S was admitted to the dark experimental room and seated before the apparatus, which was on at all times. The E adjusted the chin cup to suit S, then read the following instructions:

"This experiment is designed to investigate some of the

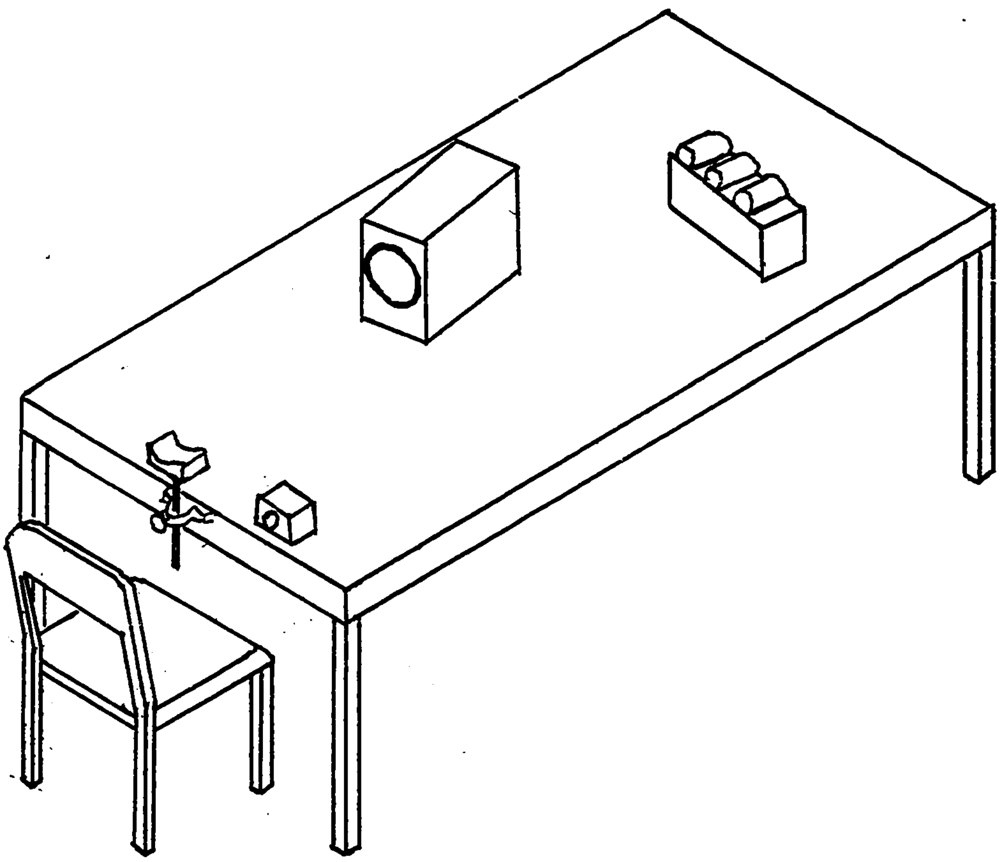

Fig. 2 Apparatus

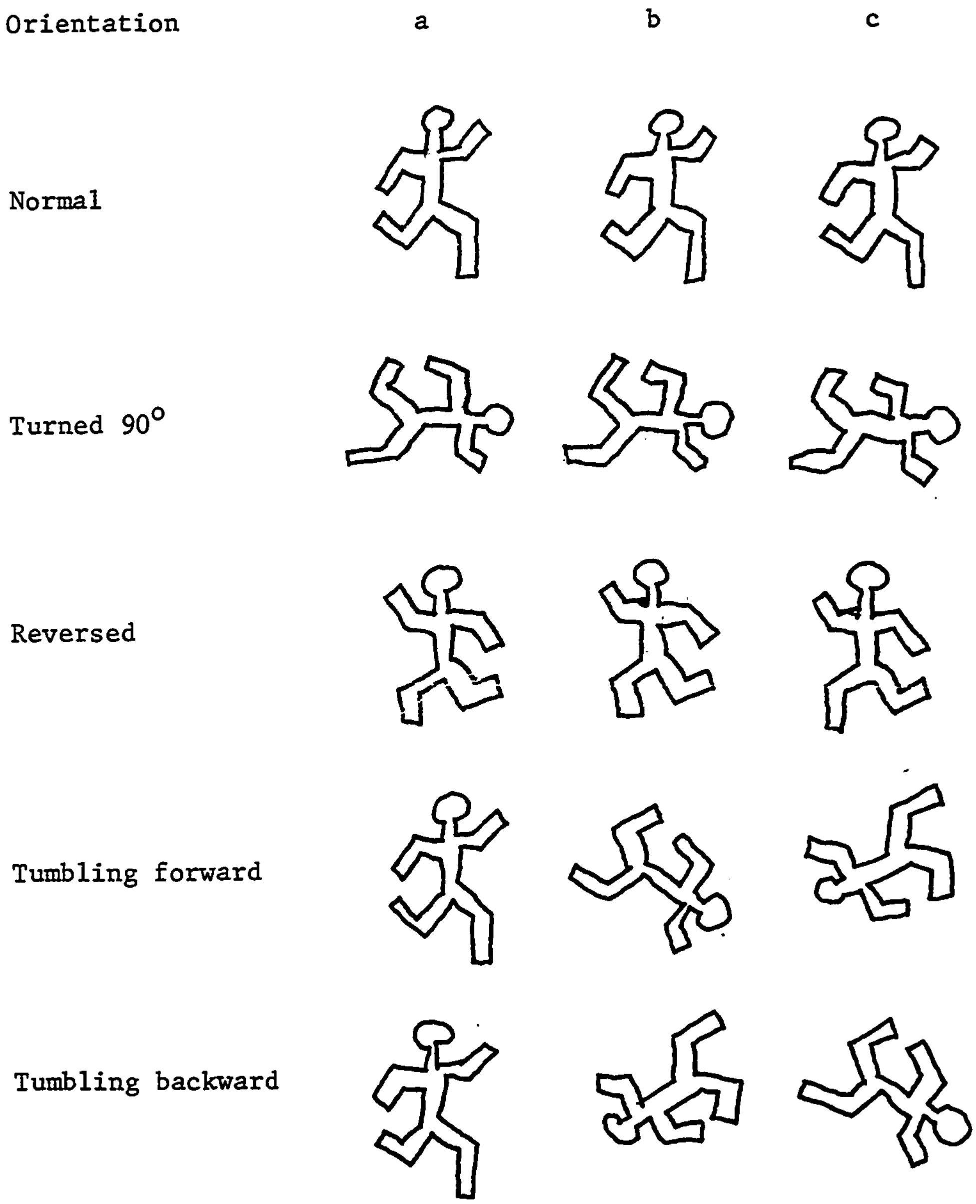

Fig. 3 Orientations of stimulus figures

factors involved in the perception of motion, especially where real motion does not exist, such as in the motion pictures or in certain types of signs which appear to move. The knob on your right/left controls the horizontal speed of the blip on this oscilloscope. Turning the knob clockwise causes the blip to slow down; turning it counter-clockwise causes it to speed up. You may adjust the knob while I continue. Your task is to adjust the knob so that the horizontal speed of the blip matches the horizontal speed of the object on the right. I am going to ask you to do this five times, that is, to make five adjustments. You may take as much time as you like to make each adjustment. As soon as you have made an adjustment, simply tell me so and remove your hand from the control knob momentarily while I read and record the dial setting with this small penlight. I will then reposition the knob one way or the other and ask you to adjust it again. Please note that it is electronically impossible to adjust the knob in such a fashion that the blip and the object on the right will start and stop at the same time. Therefore please do not waste time trying to match or allign them in that manner. Concentrate only on horizontal speed in the direction of left or right."

After S had made and E had recorded five adjustments, S was thanked for his/her time and cooperation and dismissed. E requested that S not discuss the experiment with any potential Ss until the end of the experiment.

RESULTS

The data were subjected to a two-way analysis of variance as described by Hays (1963) and summarized in Table 1. While the orientation and the figure x orientation interaction effects produced significant F values ($p < .01$), the figure effect did not. A series of t tests was conducted on the data to determine the reason for this failure of the figure effect to attain significance. The results of these t tests are summarized in Table 2. Note that in the turned 90° and tumbling forward orientations the differences exhibited in the normal, reversed, and tumbling backward orientations vanished. This lack of figure differences in two orientations is sufficient to cause the figure effect to be nonsignificant in the analysis of variance.

In Table 2 the row and column headings are arranged in descending rank order by perceived speed.

Table 3 presents the perceived speed of each figure in each orientation. The figures are presented in rank order by speed. Note that an almost complete reversal of rank order occurred between the normal and reversed orientations. Those figures perceived as faster under normal conditions became slowest under reversed orientation. Table 2 confirms that in both orientations, several of the differences between mean speeds for figures were significant ($p < .01$).

Table 4 summarizes another series of t tests conducted to pinpoint the significant differences between orientations of each stimulus figure.

Table 1

Analysis of Variance Summary

Source	SS	d.f.	MS	F
Figures	1,141.1	5	228.22	1.635
Orientations	4,690.6	4	1,172.65	8.402**
Interaction	6,939.6	20	346.98	2.507**
Error (within cells)	100,480.8	720	139.56	-
Totals	113,252.1	749	-	-

**$p < .01$

Table 2

t-tests between Ordered Pairs of Mean Perceived Speeds

Normal

	sloop	woman	prop	sailboat	man
jet*		.05	.05	.01	.01
sloop					.05
woman					.05
prop					.05

Turned 90°

	sloop	sailboat	man	prop	woman
jet				.05	.05
sloop				.05	

Reversed

	man	prop	woman	sloop	jet
sailboat				.01	.01
man			.05	.01	.01
prop				.05	.05
woman					.05

Tumbling forward

	sailboat	jet	man	prop	sloop
woman					.05
sailboat					.05

Tumbling backward

	sailboat	prop	jet	man	sloop
woman				.01	.01
sailboat				.01	.01
prop				.05	.01
jet					.05

*Figures are presented in descending speed rank order. Row entries for non-significant ordered pairs are omitted.

Table 3

Perceived Speeds in inches per sec of the Stimulus Figures

Normal		Turned 90°	
1 jet plane*	17.33	1 jet plane	17.05
2 sloop	17.08	2 sloop	17.02
3 stick woman	16.98	3 sailboat	16.93
4 prop plane	16.98	4 stick man	16.86
5 sailboat	16.90	5 prop plane	16.78
6 stick man	16.74	6 stick woman	16.76
mean	17.00	mean	16.90

Reversed		Tumbling forward	
1 sailboat	17.35	1 stick woman	16.83
2 stick man	17.34	2 sailboat	16.78
3 prop plane	17.18	3 jet plane	16.78
4 stick woman	17.08	4 stick man	16.78
5 sloop	16.88	5 prop plane	16.66
6 jet plane	16.74	6 sloop	16.59
mean	17.1	mean	16.74

Tumbling backward	
1 stick woman	17.22
2 sailboat	17.16
3 prop plane	17.10
4 jet plane	17.08
5 stick man	16.78
6 sloop	16.74
mean	17.01

*Figures are presented in descending speed rank order for each Orientation.

Table 4

t-tests between Ordered Pairs of Mean Perceived Speeds

Jet plane

	tmb bkwd	turned	tmb fwd	reversed
normal*			.01	.01

Prop plane

	tmb bkwd	normal	turned	tmb fwd
reversed			.01	.01
tmb bkwd			.05	.01
normal			.01	.01

Stick man

	turned	tmb bkwd	tmb fwd	normal
reversed	.01	.01	.01	.01

Stick woman

	reversed	normal	tmb fwd	turned
tmb bkwd			.01	.01
reversed				.05

Sailboat

	tmb bkwd	turned	normal	tmb fwd
reversed		.05	.01	.01
tmb bkwd			.05	.01

Sloop

	turned	reversed	tmb bkwd	tmb fwd
normal			.01	.01
turned			.05	.01
reversed				.05
tmb bkwd				.05

*Orientations are presented in descending speed rank order. Row entries for non-significant ordered pairs are omitted.

DISCUSSION

The almost complete reversal of rank order between the normal and reversed orientations can be explicated by the notion of directional determinants and speed connotative factors. Those objects having the greatest speed connotative factors normally (jet plane and sloop) suffer most from conflict with their directional determinants, those factors normally perceived as determining direction. When apparent direction is reversed, the reversal inhibits the function of the speed connotative factors, and perceived speed is altered.

The tumbling forward orientation, like the turned 90° orientation, cancelled the effect of differential speed connotative factors, and destroyed figure differences in speed. Tumbling backward, however, produced several significant differences and a rank order of speeds unlike both the normal and reversed orientations. Possible explication of the difference between the effect of the tumbling forward orientation and the effect of the tumbling backward orientation can be obtained by recalling the Krampen and Toch (1960) and Toch (1963) studies in which the arrowlikeness of a stimulus figure was manipulated. These studies showed that the arrow has directional determinants. An arrow-like figure may also have speed determinants and connotative factors. Consideration of the leading edge or form of each stimulus figure in both the tumbling forward and tumbling backward orientations reveals that, in both, each figure is presented in identical orientations, but in different sequences (Fig. 3). If the leading edge were determining the speed connotations, it should equalize for both groups. The key factor involved must, therefore, be the effect of tumbling, which obviously must be examined and studied experimentally in greater detail to reveal the exact factors responsible.

A consideration of the sailboat in reversed orientation reveals a strong resemblance to an arrow in the lower corner of the sail, which is the leading edge in the reversed orientation, and may have accounted for the sailboat being perceived as moving significantly faster ($p < .01$) in reversed orientation than in normal orientation.

Examination of Fig. 3 further shows that in reversed orientation the stick man's leading edge is more similar to an arrow than is the leading edge of the same stimulus figure in the normal orientation. This difference in leading edges may be responsible for the significant ($p < .01$) differences in perceived speed, with reversed orientation faster than normal. Note that this difference is not apparent in the perceived speeds of the stick woman under normal and reversed orientations. Perhaps the skirt equalized directional determinants.

Clearly the data generated by this investigation are insufficient to unquestionably explain all the differences discovered. Further research should be directed at isolating speed connotative factors. More attention should be devoted to aerodynamic factors involved in stimulus figure character in an effort to isolate directional determinant factors.

Further investigation of the differences between the effect of tumbling forward and tumbling backward is needed. A suggested initial tactic would involve breaking the tumbling effect into smaller segments, presenting perhaps 90° of a fall at one time. This technique would show which if any quadrant of a tumble was influential in enhancing differences in speed connotative factors and/or directional determinants. This type of experimentation might also point up the crucial differences between the forward and backward tumbles.

Comparison of the data obtained in this study with the data of Lyngen (1967) shows that in the normal orientation the perceived speeds of the sailboat and stick man, which were identical to Lyngen's figures, are very similar. The only obvious difference in perceived speed is in the case of the jet plane, which was reported by Lyngen's Ss, who each viewed seven stimulus figures in a random sequence for two trials on each stimulus figure. The random groups design employed in this study precluded intra-S interactive effects such as contrast.

SUMMARY

This study was conducted with 150 subjects placed in a random groups design to determine the effects of cue conflict on apparent visual motion. Six stimulus figures were presented in five orientations via a modified phi apparatus. The results supported the hypothesis that the different orientations of the stimulus figures would produce differences in perceived speed. Reversing the orientation of the stimulus objects reduced the apparent speed of those stimulus objects perceived to be fastest in the normal orientation and increased the perceived speed of those objects perceived as slowest in the normal situation. Turning the stimulus objects 90° clockwise or presenting the stimulus object as tumbling forward destroyed all differences found with the other orientations. The results were discussed with reference to previous research of apparent visual motion. Suggestions for further examination of several of the differences produced by this study were made. Possible tactical modifications of the stimulus objects were also discussed.

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