Arm-movement responses to Müller-Lyer stimuli¹

FRANKLIN L. MOSES AND MICHAEL J. DeSISTO^{2,3}
TUFTS UNIVERSITY

*Similarities between eye- and arm-movement patterns during the Müller-Lyer illusion were investigated. The study was designed to find out if characteristics of a visual illusion would be reflected in tracings of an unseen arm. Six stimuli, three experimental and three control, were presented five times to each of seven Ss who were familiar with the illusion. Data were analyzed by measuring lengths of tracings and by making intraindividual comparisons using *t* tests for correlated means. Results for the arm were similar to those reported elsewhere for the eye. Arrows with outward-directed obliques were traced longer than arrows with inward-directed obliques, as well as longer than control stimuli. Agreement between eye- and arm-movement responses to the illusion lend support for using each technique to investigate stimuli that affect man's distance metric.*

Psychologists have tried to explain the apparent difference in lengths of the Müller-Lyer arrows since the illusion was first demonstrated in 1889. Various investigators (e.g., Delabarre, 1897; Judd, 1905; Stratton, 1906; Yarbus, 1967; DeSisto & Moses, 1968; Festinger, White, & Allyn, 1968) have described eye-movement patterns during perception of the illusion. One predominant finding of these studies was that eye movements tend to undershoot the perceptually short side of the illusion and to overshoot the perceptually long side. Stratton (1906) found enough variability in the pattern of eye movements to conclude that they do not cause the illusion but may instead be its effect. However, Festinger et al (1968) advanced the hypothesis that efferent readiness for control of eye movements was responsible for perception of the illusion. The present paper emphasizes the similarity of arm-movement patterns to eye-movement patterns rather than the disagreement (cf. McLaughlin et al, 1969) about the role of the eye in the Müller-Lyer illusion.

In a previous report (DeSisto & Moses, 1968), evidence was presented that a single (quick) saccadic eye movement would initially overshoot an outward-directed oblique and undershoot an inward-directed oblique of a Müller-Lyer stimulus. The experiment differed from previous investigations since Ss were asked to make

a saccade from one vertex of the illusion to another rather than to just move their eyes across the illusion. Saccadic eye movements were monitored by the photoelectric technique (Torok et al, 1951; Smith & Warter, 1960; Stark et al, 1962). Each initial saccade was classified as an overshoot or an undershoot by comparing detector output at the termination of the initial saccade with detector output 1 sec after termination of the initial saccade. The most frequent response to the shaft with inward-directed obliques (see Fig. 1E1) of the Müller-Lyer stimulus was an undershoot. The most frequent response to the shaft with the outward-directed obliques (see Fig. 1E2) of the stimulus was an overshoot.

The present study involving arm movements was a companion to the one using saccadic eye movements. Ss were asked to draw the apparent size of Müller-Lyer stimuli as well as control stimuli in a blind (i.e., no visual feedback) tracing situation. The procedure differed from the ones used in other studies by not emphasizing matching of one Müller-Lyer arrow to the other and not visually guiding an arm-movement adjustment to the perceived arrow lengths. The general hypothesis was that arm movements should behave similarly to eye-movement patterns made to Müller-Lyer stimuli. Specifically, an arm-movement record should: (1) undershoot the inward-directed obliques of the illusion and (2) overshoot the outward-directed obliques of the illusion. The intention of the study was to find out if characteristics of the visual illusion would be reflected in tracings of an unseen arm.

METHOD

Apparatus

The experiment was done in a dimly lit room. The stimulus display consisted of a holder into which each of six stimulus cards could be placed. The stimuli are shown in Fig. 1. Each of the horizontal lines is 3 cm long, the obliques and uprights are each 1 cm long, and the obliques are at a 45-deg angle from the horizontal. The stimuli were viewed at a distance of 33 cm.

A drawing area was placed at heart level and at a slope of approximately 30 deg on a table directly in front of S. S was provided with sheets of paper and an

ordinary pencil for tracing purposes. Tracings were hidden from S by a chin-level horizontal surface that served to hold a bite-board mount and the stimulus display.

Subjects

Seven college students, five female and two male, were Ss. They all reported that they could see the stimuli clearly, the only requirement of the experiment.

Procedure

A bite board containing S's dental impression was made to hold his head steady during the task. The bite board was mounted on a sturdy table and could be adjusted so that the stimulus display was at eye level. The right end point of each experimental and control stimulus display was placed directly in front of S's right eye. S was told that while on the bite board he would make eye movements from the right vertex or end of a stimulus to the "center" of a stimulus (if a center point was marked on a stimulus) and then to the left vertex or endpoint. S was told that after eye movements to each stimulus, he was to draw the stimulus as quickly and accurately as possible while still on the bite board. The complete illusion (see Fig. 1E3) was explained to all Ss in order to eliminate any uncontrolled variable of surprise. Most Ss were familiar with the illusion prior to this experiment, and accurate reproduction of what they were to presently see was emphasized.

Each stimulus was presented once and then S was given a 2-min rest period. This procedure was repeated until S had seen all stimuli five times.

Fig. 1. Experimental (E) and control (C) stimuli (not to scale).

Table 1

Summary of t-Tests Comparing Differences Between Tracings to Experimental and Control Stimuli

Stimuli Compared	α	df	t-Value
E1 vs C1	.05	6	-2.89***
E1 vs C2	.05	6	.073 ⁺
E2 vs C1	.05	6	-1.44*
E2 vs C2	.05	6	1.41*
E3 vs C3	.05	6	.468 ⁺ ; -3.19***
C1 vs C2	.05	6	4.25****
E1 vs E2	.05	6	-1.51*
E3 (1 vs r)	.05	6	3.19***

⁺ not significant; **** $p = .005$; *** $p = .01$; * $p = .10$

RESULTS

Tracings of the illusion and control stimuli were measured and then analyzed by using t tests for correlated means. Each S's responses to individual stimuli were averaged and differences were taken for comparison of results. Experimental stimuli were compared with control stimuli, except in the two cases in which the illusion's arrows (see Figs. 1E1, 1E2, and 1E3) were compared.

Table 1 is a summary of the t test results for comparisons of tracings to various stimuli. Tracing responses for the complete illusion (see Fig. 1E3) were only partially different from the control stimulus (see Fig. 1C3). The right-hand side of the illusion figure was traced 19.9% longer than the right-hand side of the control, but there was no significant difference for the left-hand side of the two stimuli (although the tracing of the illusion was slightly shorter). The experimental stimulus with the inward-directed obliques resulted in a response that was 8.4% smaller than the experimental stimulus with the outward-directed obliques. An even greater difference was found when the two halves of the complete illusion (see Fig. 1E3) were compared. There was no significant difference between the arrow with the inward-directed obliques and one control stimulus (see Fig. 1C2), but the same arrow was 18.4% smaller than the other control (see Fig. 1C1). The discrepancy in results with the two control stimuli was due to the fact that the stimuli were traced as being greatly different. Responses to the arrows with the outward-directed obliques were not quite significantly different from either of the control stimuli. There again was an interaction effect with the two controls. The arrow with the outward-directed obliques was drawn 10.8% shorter than the straight-line control and 9.6% longer than the control with the two uprights.

DISCUSSION

The tracing results were contaminated by perceived differences in lengths of the control stimuli. In spite of this problem, the trend of results was in the direction of experimental predictions. The supported

trends were that arrows with outward-directed obliques are traced longer than arrows with inward-directed obliques, as well as longer than some control stimuli. Unfortunately, the straight-line control stimulus was traced 22.9% longer than the control stimulus with vertical end lines. This significant difference negatively affected the predicted results for three of the experimental comparisons: (1) Fig. 1E1 vs Fig. 1C2, (2) Fig. 1E2 vs Fig. 1C1, and (3) Fig. 1E3 (left half) vs Fig. 1C3 (left half). There was little difference between the arrow with inward-directed obliques and the control stimulus with vertical end lines in either Comparison 1 or Comparison 3. However, there was a significant difference in the predicted direction when the same arrow was compared with the straight-line control stimulus (Fig. 1E1 vs Fig. 1C1). A more striking example of a reversal of results was evident in comparing the arrow with outward-directed obliques and each control stimulus. In Comparison 3, this arrow was shorter than the straight-line control and thus contradicted an experimental hypothesis. In contrast, the same arrow was traced longer (as predicted) than the control stimulus with the uprights. The changes in results depended on whether a comparison was made between a control stimulus with distinct end points or just a straight-line stimulus. This difference in stimuli seemed to create an illusion of length that should be investigated. The value of the tracing method for such investigations is supported by two aspects of the present experiment: (1) The two control stimuli were consistently shown to be different from S to S, and (2) the difference between the control stimuli and the Müller-Lyer stimuli interacted systematically.

A direct comparison of the length of one Müller-Lyer arrow with the length of the other one produced interesting results. The two halves of the complete illusion (see Fig. 1E3) lead to a more pronounced difference in tracings than was found between tracings of the two separate arrows (Fig. 1E1 vs Fig. 1E2). The presence of both halves of the illusion

simultaneously may enhance its effect on observers. In any case, the tracings indicated that Ss were perceiving the arrows of the illusion properly in relation to each other.

In summary, tracings of the Müller-Lyer illusion parallel eye-movement records of the stimuli. Any discrepancies between saccadic eye-movement and tracing results occurred because the data from each modality did not yield entirely comparable information. Saccadic eye-movement data for Müller-Lyer and control stimuli were based on the number of overshoots or undershoots of stimulus end points; tracing records were based on the lengths of stimulus reproductions. The eye may have initially overshoot or undershot a target point, but then it accurately attained a foveal fixation. In contrast, the tracings reflected subjective judgments of stimulus end points and the distances between them. Accurate distance measures were not available from the eye-movement data. Thus, there were surprises when a few of the predictions based on visual responses to the illusion did not carry over to the blind tracing task. Tracings agreed with, as well as extended, the saccadic eye-movement investigation (DeSisto & Moses, 1968) of the Müller-Lyer illusion. Perhaps both techniques should be used to investigate stimuli that affect perceived distance. For example, some experiments (e.g., Judd, 1905; Festinger et al., 1968) have investigated decrement in eye-movement patterns that occur during prolonged visual inspection of the Müller-Lyer illusion. The present study suggests that arm movements could supplement eye movements as a means of systematically classifying and studying the experimental conditions that can cause modifications of man's distance metric.

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2. Address: Department of Psychology, Tufts University, Medford, Massachusetts 02155.
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NOTES

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