Luminous targets: Visibility fluctuations modified by similar verbal responses*

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Ss reported visibility fluctuations in a luminous target consisting of small, medium, and large circles. Each S had previously learned a response to each of the three circles. The experimental group learned two words which were free associates of each other and a third unrelated word. The control group learned three unrelated words. Concurrent visibility for the pair of circles associated with related words was greater than for the pairs associated with unrelated words. Thus word associations influence perception of stimuli for which the words are responses.

Although perception ordinarily depends upon the stimulus, other influences can be demonstrated when the stimulus is reduced in strength or complexity. A phenomenon which illustrates these influences is the subjective disappearance and reappearance of a set of luminous visual stimuli viewed against a dark background. The pattern of disappearances can be changed when identical responses are learned for some of the stimuli (Donderi & Kane, 1965). This is interpreted to mean that the phase cycle representing a common response correlates neural activity in phase cycles representing its stimuli (Hebb, 1949). Other evidence that learned associations affect perceptual organization has been obtained by McKinney (1963, 1966) and by Tees and More (1967a, b) using similar techniques.

Since identical responses influence stimulus disappearances, two related but not identical responses might also influence the disappearances albeit less strongly. Donderi and Kane assume that an identical response adds a "common element" to both neural stimulus representations, providing a phase cycle linkage between them which maintains their coincident activity (Hebb, 1949, p. 130). The concept of "common elements" can also be applied to related response words. The proportion of "common elements" in two words can be assumed to increase as the frequency with which they are given as free associates of each other increases.

Following this reasoning, one set of three response words was chosen so that two words were frequent free associates of each other and the third was an associate of neither. Another set of words was chosen so that none was a close associate of any other. The response words were then paired with

three stimulus circles of different size in a paired-associates learning task. Afterwards, the three circles were presented together as luminous stimuli and their observed disappearances and reappearances were recorded. A significant coincidence between the visibility states of circles paired with the related words would be considered evidence that related responses influence perceptual organization.

METHOD

Stimuli

Stimuli were three circles 0.65, 1.27, and 1.91 cm in diam. During learning, they were white on black 7.6 x 12.7 cm (3 x 5 in.) cards. In the darkroom, they were luminous at 0.03 c/m². The source was an incandescent bulb diffused by onion skin paper. In both tasks stimuli were viewed at eye level 56 cm distant, and subtended visual angles of 0 deg 38 min, 1 deg 15 min, and 1 deg 53 min.

Responses

There were two response sets, each of three words. The experimental set was *boy, girl, fish* and the control set was *light, goon, rough*. *Boy* and *girl* are free associates but none of the others are. *Boy* was the most frequent associate to *girl* ($p = .36$ to $.82$) in all eight studies summarized by Shapiro and Palermo (1968), whose review furnished the association data. *Girl* was the most frequent associate to *boy* ($p = .61$ to $.82$) in all nine studies summarized. The most frequent response to *fish* was *water* ($p = .11$ and $.13$ in two studies). The most frequent associate for *light* was *dark* ($p = .21$ to $.59$ in 10 studies). One study gave *bulb* ($p = .29$) as the most frequent response. The most frequent response to *rough* was *smooth* in all seven studies ($p = .23$ to $.56$). *Light, boy, girl* and *fish* occurred at least 100 times per million in the Thorndike-Lorge (1944) count, *rough* appeared at least 50 times per million,

and *goon* did not appear as often as 4 times per 18 million words. This ranking agrees with West's (1953) word count.

Subjects

Twenty-four English-speaking high school and college student volunteers (10 women) were paid for participating in a series of vision experiments. One S did not complete this experiment. They were assigned randomly to the control and experimental groups and to the words-circles combinations within each group, with the restriction of equal N in each condition. The learning and darkroom tasks were presented as unrelated parts in this series of experiments.

Learning Task

The Ss learned to associate one of the three words to each of the three circles. The experimental group ($N = 11$) learned *boy, girl, and fish*, and the control group ($N = 12$) learned *light, goon, and rough*. Words and circles were paired in a Latin square within the experimental and control groups. Three Ss were assigned randomly to each circle-word combination, but one S in the originally assigned experimental group of 12 Ss failed to complete the experiment. The design is illustrated in Table 1.

Stimuli were presented manually in a single predetermined random order. Each presentation lasted about $\frac{1}{4}$ sec, with an interval of about 3 sec between each presentation. E said "right" or "wrong" after each response. Each stimulus circle was shown 40 times, giving a total of 120 presentations.

Darkroom Task

The three luminous circles were displayed 56 cm distant at eye level perpendicular to the S's line of sight. Their centers were located 2.8 cm from a luminous fixation point and equidistant from each other at 0, 120, and 240 deg. S was seated at a table, his head supported by a chinrest. Three pushbuttons were on the table in front of him. Each operated a separate pen on an event recorder.

An eye patch covered S's nonpreferred eye. S dark-adapted for 20 min while listening to a tape recording instructing him how to respond to the observed fluctuations in visibility. He was told to press the button corresponding to each circle as long as it was visible. Ss practiced using the buttons by following a tape-recorded sequence of imaginary visibility configurations equally balanced among all possible patterns. Following the adaptation and

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Table 1
Duration of Visual Coincidence for Circle and Response Pairs: Experimental Group

S	Proportional Duration			Total Duration (Sec)
	Boy-Girl	Boy-Fish	Girl-Fish	
1	511 ml	271 sm	218 sl	48
2	508	354	138	39
3	740	043	217	12
4	627	168	209	67
5	516 sm	153 sl	331 ml	62
6	855	060	085	117
7	816	082	102	153
8	412	247	341	41
9	462 sl	308 ml	230 sm	65
10	623	145	232	34
11	555	167	278	27

Note—Circle pairs indicated as follows: sm = small-medium, sl = small-large, ml = medium-large
Proportional durations = entries $\times 10^{-3}$

instruction, Ss viewed the stimulus for 5 min in one orientation and for 5 min in a different orientation. During the first 5 min, the medium (1 deg 15 min) circle was at 0 deg, the large circle (1 deg 53 min) at 120 deg, and the small circle (0 deg 38 min) at 240 deg. During the second 5 min, the position of the small and large circles was reversed. There was a 10-min rest period in the dark between the sessions.

Data Analysis

There are eight visibility states in the set of three circles. These are: all circles visible, all invisible, two visible and one invisible (three possibilities), and two invisible and one visible (three possibilities). Two circles are in visual coincidence when either both are visible or both are invisible exclusive of the third. The frequency or the total duration of visual coincidence of circle pairs accounts for six of the eight visibility states. The other two states, all three circles either visible or invisible, contain no information about the differential visual coincidence of pairs of circles. They were ignored. The results for each pair of circles from each S were expressed as a proportion of the total duration or frequency of all three pairs for that S. The total duration data for each S was retained and is also presented in Table 1.

RESULTS

Learning Task

No S required more than 15 trials before responding correctly. Thus, all can be considered to have reached the asymptotic performance permitted by the 120 trials.

Darkroom Task

The effect of the response word pair *boy-girl* was to increase the visual coincidence of every pair of circles associated with them (Table 1). The proportional duration of visual

coincidence was higher for the circles associated with *boy* and *girl* than for either of the other two pairs, *boy-fish* and *girl-fish*, for all 11 of the Ss in the experimental group. But the most coincident pair in the control group was not always associated with a particular set of response words. The circles associated with *light-noon* were more coincident for 2 Ss (mean proportion $[\bar{p}] = .331$), with *light-rough* for 4 ($\bar{p} = .326$), and with *noon-rough* for the remaining 6 Ss ($\bar{p} = .346$). Visual coincidences based on frequencies give the same results. The total frequency in the experimental group ranged from 11 to 105, and the visual coincidence was always greatest for the circles associated with *boy-girl*. Control-group frequencies ranged from 12 to 70, and circles associated with each of the three word pairs were most coincident for 4 of the 12 Ss.

The prior probability that coincidences of circles associated with *boy-girl* would be greater than the other two circle pairs is one-third. On this assumption, the exact probability of the obtained result is 5.6×10^{-6} for both duration and frequency data. The distribution of either duration and frequency coincidences in the control group is not significantly different from that expected under the prior assumption of equal probability.

Afterwards, the experiment was explained to each S, who was asked specifically if he had assumed any connection between the learning and the darkroom task. No S said that he had assumed any connection between them.

DISCUSSION

In Hebb's (1949) theory, one phase cycle representing a concept or percept can share cell assemblies with another one. This is how an increase in visual coincidence with increased similarity between pairs of stimuli was explained (Donderi, 1966). Our

present results indicate that responses are also organized as phase cycles. Two responses integrate the stimulus-based phase cycles with which they are associated, to the degree that the response phase cycles share cell assemblies. This correlates with how frequently the response words are free associates of each other.

Similar phenomena (Donderi & Kane, 1965) have been explained as due to attention (Gibson, 1969, p. 72). Prior instructions do change the pattern of luminous stimulus disappearances (McKinney, 1966). But the term "attention" applied to this type of result means only that something other than common responses or stimulus pairing also influences the disappearance pattern. In our experiment, if S was paying attention, he was attending to two circles with related responses. Thus our explanation for attention is also that it depends on the integration of phase cycles with common cell assemblies.

Finally, Neisser (1967, p. 80) explains McKinney's result by suggesting that S reports quite unconsciously what he assumes E expects him to report. But this did not happen in our experiment, because no S had any idea what E wanted him to report.

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