The effect of repetition on the perception of single letters¹

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Single letters were presented for from one to five flashes, with S required to report what he saw after each flash. The clarity of the letter increased sharply with repetition. Since the letters were no larger than one-third of a degree in size, clarity could not have been increased by S making different fixations from flash to flash and combining them into a total percept. Nor was S guessing, since this could be ruled out by other indicators. Thus, it was concluded that repetition of the stimulus can have a direct effect on the clarity of a S's percept of that stimulus.

A series of studies by Haber (1965), Haber and Hershenson (1965), and Hershenson and Haber (1965) has shown that the clarity of letters of words increases with the number of widely spaced exposures, independently of the duration of the exposures (within limits), the familiarity of the words, the frequency of the words, and whether or not the S knows exactly what the word is to be. Further, this effect of repetition on clarity follows the same function irrespective of these other conditions of the experiments.

Because of this invariant relation of repetition to clarity over such a wide range of stimuli and experimental conditions, Haber (1966) argued that these conditions were affecting clarity directly rather than being mediated by guessing, response selection, or some other nonperceptual process.

One alternative explanation that could be offered, though the supporting arguments are quite tenuous, is that repetition increases clarity because the S changes his fixation with each flash—first looking at the first few letters, then in the middle, then in the end, etc. In this way he might see all of the individual letters, though on different flashes. Following an assumption that once having seen the letter it is easier to see it again, this might account for the increase in clarity without any need to assume any direct effect of repetition on clarity. It is also being assumed here that the S is not using these differential fixations to *guess* what the word might be, even though he may have seen all of the letters at one time or another. Previous data already referred to strongly suggest that the Ss are not guessing in this type of experiment, but are in fact reporting the clarity of the letters that they see.

A very easy test of this alternative explanation is to examine the effect of repetition on clarity for a stimulus small enough to make scanning or changes in successive fixations unnecessary. To do this, the same basic experiment was repeated, using single English letters as the stimuli. Any increase in clarity with repetition for these

stimuli could not be then due to changes in fixation, but rather to some more direct effect of repetition itself.

Method

Two experiments were run which differed in Ss and in the construction of the lists of stimulus orders. Otherwise they were identical. They will be discussed together.

Subjects. In the first experiment three Undergraduate paid volunteers from the University of Rochester, two women and one man, served as Ss. One woman completed nine sessions (of about 1-hr. duration each) while the two other Ss completed six sessions apiece. In the second experiment, three Ss were also run, including the woman who completed nine sessions in the first experiment, and two additional men. All Ss in the second experiment completed seven sessions in which data were collected.

Stimuli. The stimuli were single letters, each centered and printed on a 8-3/4 in. x 6-3/4 in. white card, using a Le Roy printing stylus No. 3240-290 CL and pen No. 3. The letters were 10/32 in. high (which gave 20 min. of visual angle at 50 in. viewing distance) and varied from 1/32 to 10/32 in. in width. All letters except Q were used. The letter cards were presented in Channel 1 of a three Channel Mirror Tachistoscope (made by Scientific Prototype Manufacturing Corporation, Model GA). A second background channel was lighted whenever the stimuli were not being presented in the first channel. The background channel contained two parallel lines 1/8 in. above and below the letters and 11/16 in. long which served as fixation boundaries.

Each letter was presented either one, two, three, four, or five times and then was changed to the next letter. The S was always told whenever a new letter was going to be presented.

The illumination was 20 ft.-L. for each channel, as assessed by a MacBeth illuminometer. The contrast ratio between the white background and the black lettering was .98. The duration of each presentation was kept constant within the session at each individual S's threshold. It was never varied within the session. Threshold was determined for each S at the beginning of each session by starting with durations well over and well under the threshold, and working to a point at which the S was responding correctly about 50% of the time. The length of time between presentations was not fixed, but varied with the speed of the S's responding. The average interval was around 3 sec. between trials for a particular letter, and about 4 sec. between letters. Data used to

locate the threshold were not used in subsequent computations.

Stimulus Order. In the first experiment all Ss were shown 30 letters once each at 30 msec. (well above their thresholds) at the beginning of each session to familiarize them with the letters, the printing, and the apparatus. Then they were shown 15 letters (randomly selected with replacement from the alphabet of 25) around threshold, following the procedure to locate threshold above. The threshold ranged from day to day in the first experiment from 3 to 4, 3 to 6, and 2 to 6 msec. for the three Ss respectively. With the duration now set at threshold, 60 more letters were shown, each for one, two, three, four, or five trials. The 60 were randomly selected with replacement from the alphabet of 25. As the Ss' performance stabilized over sessions it was found that more letters could be shown within the hour of each session, so 25 additional letters, selected in the same manner, were added to the 60. The three Ss had completed either four or five sessions before the extra 25 were added. No attempt was made to equate the number of appearances of each letter in the list. Consequently, each letter appeared from three to six times in the list of 60 and from three to nine times in the augmented list of 85. The number of times each letter was flashed was also randomly determined and then specified for each letter on the list of 60 (or 85).

The same list was used for all Ss and for all sessions. However, the E began at a different point each day, and, dividing the list into blocks, ran the blocks in a different order for each session. Thus it is only remotely possible that a S could remember orders and thus predict the next letter.

However, because this possibility did exist and more importantly, because of the single unrestricted random order repeating in each session did not equate the number of times each letter in the alphabet appeared, the second experiment was run in which this procedure was changed. Seven different lists of 90 letters each were presented, for a total of 625 letters. Over the seven lists, each letter appeared 25 times. This was also balanced over the number of trials for each letter, so that each letter appeared five times for one trial, five times for two trials, etc. No attempt was made to check counterbalancing within a list.

In addition to the 90 letters, 20 practice letters were shown at the beginning of each session (a different random list for each session) to determine the threshold using the procedure described above. The threshold for the S from the previous experiment varied from 3.5 to 4.5 msec., compared to 3 to 4 msec. earlier. The two new Ss varied from 4.5 to 6.5 and 2 to 4 msec. respectively. The carryover S received no extra sessions for practice, since she was already well practiced. The two new Ss were given five 1-hr. practice sessions using lists from the first experiment before beginning on the seven data sessions.

Procedure. At the beginning of each session in both

experiments 30 practice letters in randomized order were presented once apiece at the duration well over threshold. Then a list of 15 (20 in the second experiment) randomized letters were presented for purposes of determining thresholds. After this was done 60 (later increased to 85 in the first experiment and 90 in the second experiment) randomized letters were presented for one, two, three, four, or five trials with rest periods at S's request. The S presented the stimuli to himself at E's signal by first fixating the parallel lines and then pressing a button which flashed the letter. The S's report after each presentation was recorded by E.

In the instructions, the E emphasized that the experiment was primarily concerned with what the S saw, not what he guessed he saw. The S was therefore urged to report as best he could whether a letter, part of a letter, or just a flash of light was perceived. He was also asked to indicate his confidence that what he saw was in fact what was there, using a two point scale. It was also pointed out to S that he would not be able to predict how many flashes he would have for each letter, and would never know when he was going to have his last chance to identify what he saw. After the last trial on each letter E identified the letter for S and told him that a new letter was now going to be presented.

Scoring. Two methods of scoring the Ss' responses were used. One method (0-1) gave a score of 1 for correct identification of the letter, and a score of 0 was given for parts of a letter, an incorrect response, a flash response, or no response at all. The other method of scoring (0, 1, 2, 3) was devised to take into account both the responses in which S gave parts of letters, and the degree of certainty that S gave for his response. The criteria were as follows: a 0 was scored for an incorrect letter, for an incorrect part of a letter, for a flash response or for no response; a 1 was scored for correct part of a letter or a good guess ("G" perceived as a "C"); a 2 was scored for the report of a correct letter, but in which S indicated low confidence; and a 3 was scored for a correct letter reported with high confidence. While it was expected that the two scoring systems would be highly correlated, it was also the hope that the latter system might be more sensitive.

To determine the accuracy (on either scoring system) as a function of repetition trials, all sessions were combined for each S. A mean accuracy score was found for all of the words given only one trial, only two trials, etc. While it is possible to use as a first trial score that score for the one trial words plus the score for the first trial of the two trial words, the three trial words, the four trial words, and the five trial words—that procedure was not employed here. Previous data have shown that the same results are found using either method of combining data.

Results and Discussion

Figure 1 presents the basic findings for the two scoring systems. As is readily apparent, accuracy

Fig. 1. Accuracy of perception as a function of repetition, as measured by two methods of scoring, for three subjects in each of two experiments.

increases with repetition for all Ss in both experiments for both scoring methods. It is not possible to fit the negatively accelerated function to these data because of the difficulty in determining the asymptote. In the previous experiments most of the increase had occurred by the fifth trial. This was the basis of the decision to use only five trials per letter in these experiments. Thus it appears that with single letters, especially in the second experiment, asymptotic performance is probably not reached as quickly.

In the first experiment all Ss showed a small drop in accuracy between the fourth and fifth trial (most pronounced using the 0-1 method of scoring). This was surprising because the Ss quickly learned that they were never given a sixth trial and hence when given the fifth they knew this was their last chance to report what they saw. It was expected, and this had been supported in some unpublished data, that Ss would report with greater accuracy whenever they felt they would not have further opportunities. The finding here is opposite to this expectation. Hershenson (1965) reported a similar endpoint effect, also without being able to offer any satisfactory explanation.

As can be seen by inspection, the two scoring systems do not differ substantially in any manner. They order the performance of the Ss in the same way and indicate the same rate of increase for each S over trials. From the Ss' point of view, however, they should make a large difference since one gives him credit for partial reports, and for good errors. While on individual trials the two systems obviously can produce different scores, apparently when summed over many

trials, the net result is the same. This is analogous to previous data in which it was observed that scoring performance as correct only when the S reported seeing all seven letters of the words would give the same result as using the percentage of letters he reported as seeing.

The higher accuracy on the second experiment might be due to several factors. Since the method of determining the threshold was the same for both experiments, they cannot be due to different duration settings. The one carryover S was considerably higher on the second experiment and this might have been due to practice. This seems unlikely, however, since whatever gain she might have experienced from practice should have already been realized, and if there were gains this would have been indicated by a lower threshold for her. In fact, the thresholds were slightly higher. Since the major difference seemed to have occurred on the third, fourth, and fifth trials, the letter list for experiment 1 was examined to see, if by chance, more difficult letters appeared with these higher trial numbers. While no careful analysis was carried out, it was observed that a preponderance of the low frequency letter (W, X, Z, H, etc.) showed up for three higher numbered trials. To this extent then, experiment 2 is probably more representative of the results of this type of experiment. This, by the way, strongly argues against the Ss having profited by receiving the same lists repeatedly in the first experiment. If they were learning anything their performance should have been higher, not lower. The greater difficulty on the fifth trial might have accounted for the drop in score there, although this still shows up in one S in the second experiment.

Perhaps a word should be added about the possibilities of guessing. Several lines of evidence argue that the Ss were not guessing what the letter was, but rather were reporting what they saw. Many reports of not seeing anything or of only pieces of the letter occurred after a trial in which S reported that he saw the entire letter clearly. Since the S knew the letter had not been changed, he should continue to report the whole letter confidently if he were guessing regardless of whether he saw it or not subsequently. Further, Ss were quite willing to make partial reports even on occasions when the partial report would clearly identify a letter unambiguously. For example, S might say that he saw an "A" without the cross bar, or a backward "C." In both cases he could guess "A" or "D" and be as confident as he was of his partial report, but he chose not to. Finally, the Ss gave every other indication that they were conscientiously reporting what they saw—their percept—rather than what they thought they saw. These are persuasive arguments to anyone participating or observing Ss in this type of experiment, even though the arguments are indirect. Haber (1965) presents some additional, more direct evidence, and Haber and Meiselman (in preparation) have quite direct evidence using transformed or missing letters in words to assess false alarm rate for guessing.

Conclusions

This experiment has demonstrated that the clarity of a single letter increases with repeated exposure. This then rules out the multiple fixation argument that similar increases in clarity for multi-letter words are not due to a direct effect of increasing clarity with repetition, but rather to S using a different fixation on each exposure. That the latter occurs is probable, but this experiment shows that clarity improves even for a stimulus which can be fixated in the same way in each exposure.

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