

## INDIVIDUAL DIFFERENCES IN THE ESTIMATION OF TEMPORAL INTERVALS

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For the past year and a half the writer has been trying to find out the facts with respect to a rather classical experiment in the field of time-perception; namely, the reproduction of empty temporal intervals bounded by instantaneous sounds. Approximately two seconds following a high-pitched warning signal, the subject hears a dull click, followed after an interval by another click of exactly the same loudness and quality. He then carries out the instructions to reproduce the interval which has been sounded, by making two taps upon a key, endeavoring, without the aid of counting or any intentional rhythmical movements, to make the interval between his two taps exactly the same as the stimulus-interval.

As the result of several somewhat distinct series of investigations, involving to date the measurement of each of over 20,000 reproductions as well as the measurement of the corresponding stimulus-intervals, the answer to certain questions has been established within rather close limits. In particular it has been possible to secure dependable and definite results concerning the variability of the subjects' reproduction, that is, upon the matter of keenness and upon the question of how keenness varies with the duration of the stimulus-interval. These results show that on the average the interval reproduced most accurately (with lowest relative variability) is three-fifths of a second. Accuracy decreases beyond this interval up to about four seconds, beyond which point it remains approximately constant.<sup>1</sup>

This paper will not, however, deal with these data concerning variability or keenness, but with the constant errors. By a constant error, is meant, of course, the difference between the average of a set of reproductions and the length of the stimulus-interval that was reproduced. In the case of the constant errors, individual differences were both very striking and very troublesome.

<sup>1</sup>For a full account of this work, see "The Reproduction of Short Temporal Intervals," by H. Woodrow, *Journ. of Exper. Psychol.*, XIII, 1930, No. 6. See also the writer's article on "Behavior with Respect to Short Temporal Stimulus-Forms," *Journ. of Exper. Psychol.*, XI, 1928, pp. 259-280.

The first investigation, with eight subjects, was a rather lengthy one in which each of 13 intervals, varying in lengths from  $1/5$  sec to 30 sec, was reproduced 100 times (the stimulus-interval being given before each reproduction). The key upon which the subjects tapped, while noiseless in itself, was so connected as to reproduce a sound identical with that used to bound the stimulus-interval. In this investigation a subject worked with only one interval on any given day. Beginning with the shortest interval,  $1/5$  sec, each successive day a longer interval was used, up to 30 sec, after which the intervals were shortened daily until on the last day the work closed with the same interval with which it began. All intervals were controlled by instruments of high precision and were measured in thousandths of a second by a Hipp's chronoscope.

In this investigation, contrary to what one would expect from the existing literature, no indifference interval was revealed, i. e., no interval was found below which intervals would be overestimated and above which they would be underestimated, but on the contrary, each interval was found to be overestimated by some subjects and underestimated by others, the tendencies toward overestimation and underestimation being about evenly divided between the eight subjects in every case. Some subjects underestimated short intervals and overestimated long ones. Some did the reverse. Some varied from overestimation to underestimation irregularly with change in the length of the interval. Some subjects overestimated all the intervals. The same subject sometimes overestimated an interval on one day to a statistically reliable degree, and underestimated it on a different day. It would follow from the above facts that there is no such thing as an "indifference point" (so far as results by this method are concerned) that has significance for subjects in general. Even taken individually, for at least half of the subjects used, it would be impossible to determine an indifference point—either because their constant errors were of the same sign throughout or because they fluctuated in sign irregularly over all or a large part of the range of intervals used.

Now, as a further check on these findings, a second experiment was made on a group of 32 other subjects, using only two intervals, one short and one long, respectively,  $3/5$  sec and 4 secs. This experiment differed from the preceding ones, it should be noted, not only in the larger number of subjects, but also in the fact that the subjects never advanced beyond an initial stage of practice and in that the influence, if any, of the other intervals in the series was in the present instance practically eliminated, as it may not have been in the first investigation. The results now obtained fully confirm the findings first obtained with

regard to the interval  $3/5$  sec, since the constant errors of the various subjects were distributed rather symmetrically about zero, 17 of them being overestimations and 15 of them underestimations. With the 4 sec interval, however, the finding of as much overestimation as underestimation was not fully verified, since  $3/4$  of the subjects were now found to show underestimations. A curious result not noted in the first experiment was that when the subjects were asked afterwards whether they thought they had made the intervals too long or too short, a majority of them promptly replied "too short"—this in spite of the fact that they had been instructed to make their reproductions of such length that would seem exactly equal to the standard. This curious result indicates that the subject's impression of the length of an interval which he is in process of reproducing is different from his impression of one that he views in immediate retrospect. An interesting problem for further work will be to determine whether any considerable proportion of these subjects who at the end of the sitting report that they have made the intervals too short would with practice lengthen their reproductions so as to get rid of this impression. It would seem natural that practice would have this effect. If so, it would mean that practice might easily change the proportion of subjects underestimating the 4 secs interval from  $3/4$  to  $1/2$  or less, and thus bring the data into line with those of the eight subjects of the first investigation who acted as subject day after day, for twenty-six days, reproducing each day a different interval.

Whatever be the explanation of the discrepancy between the distribution of individual differences in the experiments reported, and this may of course be due simply to the small number of subjects used, it remains true that even in the case of the longer intervals as well as of the shorter there exists no dependable tendency upon the part of all subjects to overestimate or underestimate. While there may be a greater probability of underestimation of a long interval than of its overestimation, the conclusion seems clearly indicated that whether an interval is over or underestimated depends greatly upon the attitude of the subject during the experiment.

In confirmation of this conclusion very decided results have been obtained from still another experiment conducted in order to test it. Two sets of instructions were drawn up, modeled after the introspective reports of some of the subjects in the preceding experiments. The instructions were somewhat complex, but the main point was that in one case the subject was to listen to the sounds as a pair of sounds in the case of both the stimulus and the response interval and to avoid strain; while in the other he was to listen passively to the interval between the

stimulus sounds, being sure to note the interval between the sounds rather than the sounds, while in reproducing he was to fill the interval with strain. We may label the former instructions auditory, and the latter, strain instructions. In the case of both the short interval of  $3/5$  sec and the long one of 4 secs it was found that the strain instructions resulted in a reliably longer reproduction than the auditory instructions. With 10 subjects, only one somewhat unreliable exception occurred, this with the  $3/5$  sec interval. The auditory instructions did not always produce underestimation nor the strain instructions overestimation, but on the average the strain instructions caused the reproductions to be 60 thousandths longer (in the case of the  $3/5$  of a sec interval) and 762 thousandths longer in the case of the 4 secs interval.

The varieties and subvarieties of attitudes which subjects may take in such a simple experiment as the reproduction of the interval between two taps is bewildering. It is not contended that the difference in attitude here described is by any means the sole difference in attitude between subjects who overestimate and those who underestimate. Indeed, this could not possibly be the case. What the present experiment proves is simply that these attitudes may be extremely influential, and sufficient in some cases to determine whether a subject's reproductions will show great overestimation or great underestimation. In general the conclusion seems safe that whether any interval, long or short, is overestimated or underestimated depends upon what attitude the subject takes, and that for *any* length of interval some subjects will take attitudes that lead to overestimation and others attitudes that lead to underestimation.