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Inter-Sensory Judgments of Signal Duration [redacted]

by

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The quantity of experimental data that have been obtained in the area of time discrimination is surprisingly meager compared to the information available in other psychophysical areas. At least part of this information-lag can be attributed to a lack of agreement concerning the nature of the perception of time. Time perception has been treated at times as a dimension of the other sense modalities and at times as though it involved a separate sense. Lack of information concerning the central physiological mechanisms associated with time perception has contributed to the problem. Thus, for example, while researchers have investigated such attributes of the visual stimulus as intensity and hue, the discrimination of the duration of the stimulus has been avoided, as though it involved a separate sense mode.

Most of the research concerned with time discrimination has employed auditory stimuli. Pure tones have been used to denote the interval to be discriminated, or auditory clicks have been used to mark-off "empty" time intervals. A few studies have investigated the discrimination of visual durations. To the extent that the studies using visual and auditory stimuli are comparable in design, their results are in general agreement. For example, the Weber Fraction $\Delta t/t = K$ (where t = time and Δt = the difference threshold, i.e., that increment in time that is discriminated with a probability of .75), seems to hold at about 1:10 for durations in the region of one to two seconds.

Essentially no data have been presented that are the result of direct comparisons of visual and auditory signal durations. The present study was designed to supply information concerning such cross-modality comparisons. In this study, visual and auditory signals were presented for both inter- and intra-modality comparisons of duration, using a standard two-choice, forced-choice experimental design.

METHOD

Subjects.- The experimental subjects were twelve male college freshmen and sophomores, ranging in age from seventeen to twenty-two years. All were free from at least gross visual or auditory impairment as determined by an informal interview.

Apparatus.- The subjects sat in a dimly lighted, sound attenuated room, wearing earphones. A 7mm diameter lens, and two push buttons, were mounted on a display panel in front of the subject, as shown in Figure 1. The push buttons were used to record the subject's response. The auditory signal, a 1000Hz (cps) tone was presented through the earphones (Permoflux, D4S-17) at a moderate but clearly discriminable level of intensity. A white noise (100KHz, low pass) background was presented through the earphones at a considerably lower intensity than

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the tone. The light source for the visual stimulus, a glow-modulator tube (Sylvania, R1131C), was mounted behind and was viewed through the lens on the panel. Both the light and the tone were gated by a solid state switch.

Procedure.- Each of the twelve subjects was tested for a total of 24 experimental sessions, each session consisting of 512 trials. On each trial two signals of unequal durations were presented; the first signal was longer on one-half of the trials, shorter on the other half. The subject's task was to judge which of the two signals was longer by pressing one of the two response switches on the display panel.

Three different pairings-of-durations were investigated: 0.5s (seconds) with 0.6s, 1.0s with 1.1s, and 1.5s with 1.6s, (hereafter these pairings will be designated by the base durations, 0.5, 1.0, and 1.5, respectively). The incremental duration was constant at 0.1s. Only one of the three base durations was presented during a single experimental session; thus, the 24 sessions consisted of eight sessions with each of the three base durations.

Each signal consisted of a light or a tone, so that on any given trial the subject was presented either two lights (S_{VV}), two tones (S_{AA}), a tone followed by a light (S_{AV}), or a light followed by a tone (S_{VA}).

A trial began with the onset of the background noise and ended with its offset. The sequence of events on the trial and their durations were as follows: noise alone (ready period), 1.0s; noise plus first signal, varied duration; noise alone, 0.8s; noise plus second signal, varied duration; noise alone (response period), 2.0s; no noise (intertrial interval), 2.0s.

The eight types of trials, consisting of the four stimuli (S_{VV}, S_{AA}, S_{AV}, and S_{VA}) times the two orders of signal duration (first or second signal longer) were presented throughout a given session in a sequence that was randomized within blocks of 128 trials, with 16 of each of the trial-types in each block.

RESULTS AND DISCUSSION

In Figures 2, 3, and 4, each data point is an average of the performance of the twelve subjects. Figure 2 shows the probability of a correct response, $Pr(R_c)$, plotted over the eight sessions for each of the four stimuli. Each of the three graphs in Figure 2 displays the data for one of the three base durations. The S_{AA} curve for the 1.0 base duration conforms with previously published results showing that the difference threshold for two auditory signals is approximately one-tenth of base durations near one second. The evidence in Figure 2 that performance becomes more accurate as the incremental duration becomes larger, relative to the base duration (as $\Delta t/t$ becomes larger), is also consistent with the results of previous research.

Discrimination of signal duration was most accurate when two auditory signals were compared. For each base duration the S_{AA} curve is higher than the other curves over each of the sessions. Additional evidence of the superior accuracy in judging two auditory signals is given by individual subjects' data. Of the twelve subjects, a majority performed best to S_{AA}, with each base duration, as follows: nine with

0.5 ($p < .001$), ten with 1.0 ($p < .001$), and eight with 1.5 ($p = .0024$).

Next most accurate seem to have been judgments comparing the durations of two visual signals. For the 0.5 base duration the S_{VV} curve stands completely above either the S_{VA} or S_{AV} curves. The 1.0 and 1.5 graphs, however, show that this superiority decreased as the base duration became longer (as $\Delta t/t$ becomes smaller).

The accuracy of performance when both signals were presented to the same modality, $(S_{AA} \cup S_{VV})$, was compared with the accuracy of performance when the signals were presented to different modalities $(S_{AV} \cup S_{VA})$. Again, considering the performance of in[illegible]ects, a majority performed best to $S_{AA} \cup S_{VV}$, with each base duration, as follows: twelve with 0.5 ($p < .002$), eleven with 1.0 ($p = .006$) and nine with 1.5 ($p = .14$).

Figure 3a, $Pr(R_V \mid S_{AV} \cup S_{VA})$, shows for each of the three base durations, the probability of a judgment that the visual signal was longer, $Pr(R_V)$, given a stimulus requiring a cross-modality comparison, S_{AV} or S_{VA}. The figure shows that the visual signal was judged longer than the auditory in each session with the 0.5 base duration. Considering the individual subject's data (0.5 base duration), for eleven of the twelve subjects the probability of judging the visual signal longer than the auditory was above 0.5 ($p < .006$). With base durations 1.0 and 1.5, the bias toward judging the visual signal as longer diminished. With the 1.5 duration there is a suggestion that the bias has been reversed; over six of the light sessions, the probability of judging the visual signal longer is less than 0.5 and only four of the twelve subjects judged the visual signal longer more often than the auditory.

The relationship between $P(R_V)$ and base duration holds, regardless of the order of presentation of the visual and auditory signals. This is shown by Figures 3b and 3c which present $Pr(R_V \mid S_{AV})$ and $Pr(R_V \mid S_{VA})$.

Figures 4a and 4b present $Pr(R_1 \mid S_{VV})$ and $Pr(R_1 \mid S_{AA})$, the probability of judging the first signal longer than the second, given S_{VV} and S_{AA}, respectively. In these two cases, where signals of the same modality are compared, there is an order effect. For both of these stimulus conditions, it will be seen that $Pr(R_1)$ decreases as the base duration increases (i.e., as $\Delta t/t$ becomes smaller). In other words, as the discrimination became more difficult, there was an increasing tendency for the second stimulus to be reported as longer. It will be noted that the 0.5 probability lines of Figures 4a and 4b represent unbiased performance with respect to the order of presentation. The responses to S_{VV} and S_{AA} are arranged differently relative to the 0.5 probability line. In the former case there is virtually always a bias to respond to the second signal as longer. In the case of responses to S_{AA}, however, the shorter base durations are always associated with a greater than 0.5 probability of judging the first signal as longer. In addition, there is an apparent tendency for the responses to S_{AA} to converge toward 0.5 probability, i.e., for biases to respond more often, either to the first or second signal, to disappear. This phenomenon does not occur in the case of responses to S_{VV}.

To conclude, the results of this study have given evidence of the following:

1. Comparative judgements of signal duration are more accurate when the two signals are presented to the same sense modality than when comparisons must be made across modalities. In addition, comparisons seem to be more accurate when the two signals are auditory than when they are visual.

2. Additional analysis showed that within the range of durations investigated (0.5 to 1.5 seconds) the tendency to judge the visual signal to be longer than the auditory seems to increase as the incremental duration becomes a larger portion of the base duration.

3. Where signals to the same modality are compared, the probability of the first signal being chosen is a function of $\Delta t/t$.

4. It is suggested that any theory which intended to relate the judgment of time to signal duration must take into account the sense modality stimulated by the signal as well as its duration.