INFLUENCE ON TIME INTERVAL CATEGORIZATION OF DISTANCE BETWEEN MARKERS LOCATED ON A VERTICAL PLANE

Isabelle Guay and Simon Grondin
Université Laval, Québec, Canada
Email: simon.grondin@psy.ulaval.ca

ABSTRACT

In this experiment, participants had to categorize temporal intervals as short or long. The intervals were marked by two brief visual signals. The signals were delivered from three potential locations on a vertical plane in front of the participants, above (A), middle (M), and below (B). Categorization of intervals marked by A-M, M-B and A-B sequences were compared, as were M-A, B-M, and B-A sequences. The main finding is that, for both ranges of durations under investigation (160 and 320 ms), the greater the space between signals (A-B or B-A), the shorter the perceived duration. This is inconsistent with the kappa effect, but can be accounted for by an attentional hypothesis.

On what basis do people make judgments about time? Most contemporary researchers in the field of time perception, like animal timing researchers, would answer this question by referring to an internal-clock hypothesis. Such a central clock is usually described as a pacemaker-counter device, with the first structure emitting pulses accumulated by the second one (Grondin, 2001). It is this accumulation that forms the basis on which time is estimated.

One challenge with an internal-clock hypothesis consists in accounting for the variability of performance levels when slight variations of nontemporal factors are introduced in experiments. This variability, in a duration discrimination task for instance, can be provoked by varying the markers' structure (filled or empty) or length (for empty intervals), or by the sensory mode used to mark intervals. Some of these effects can be accounted for by some simple explanation such as the "internal-marker hypothesis" (Grondin, 1993). Variability in temporal processing is also produced by introducing nontemporal processing during an interval to be judged: this variability is usually accounted for by attentional explanations (Zakay, Block & Tsal 1999).

The present experiment is concerned with the effect on time judgments of another form of nontemporal factor—space. Different veins of literature in experimental psychology involving visual perception, such as time-to-collision or apparent movement, are composed of a mixture of time and space considerations. One is of special interest here, the kappa effect (Jones & Huang, 1982): time judgments are influenced by distance between visual sources marking time. The effect is usually shown to be robust in conditions where three successive signals (say, X, Y, and Z, with Y somewhere in between X and Z) are delivered. For two equal time intervals defined by the onset of two signals, X-Y or Y-Z, duration is perceived as longer for the X-Y than for the Y-Z sequence if the distance between X and Y is greater than the distance between Y and Z.

The subject of the present experiment is the effect of the distance between flashes in conditions where a judgment is made after presenting one interval (two flashes) rather than after presenting two intervals (sequence of three flashes). Three signals are used, located on the same vertical plane, with a flash placed midpoint between the other two. If space is taken into account as in the kappa effect, a sequence marked by the upper and lower signals should be perceived as longer than signals involving the mid-point flash. What is more, given that what is higher in the visual field is usually perceived as being farther away, it is expected that intervals marked by the middle and above flashes should be perceived as longer than those marked by middle and below flashes.

Method

Participants
Twenty-four 20- to 36-year-old paid volunteer students at Université Laval participated in this experiment.

Apparatus and stimuli
The intervals to be discriminated were a silent duration between two 20-ms visual stimuli. The visual stimuli were produced by a circular red light-emitting diode (LEDs: Radio-Shack #276-088) placed about 1 m in front of the participant, subtending a visual angle of about $.57^0$. The LEDs were on the same vertical plane, with about 25 cm between the one Above (A) and the one in the Middle (M), and 25 cm between the latter one and the one Below (B). The eye-level of participants was the height of M; participants were asked to look at M.

Each observer was seated in a chair in a dimly lit room and asked to respond either "short" or "long" by pressing the left or the right button, respectively. Adjacent to each button on the response box was a small light used to provide feedback after each trial. All other aspects of the experiment were controlled by a microcomputer.

Procedure
Each trial consisted of the presentation of one of six (6) intervals. The participant was asked to judge if the time interval between the two sensory signals was short or long. A 1.7-s feedback signal was presented 200 ms after the response, followed by a 1-s inter-trial interval. Feedback indicated whether the presented interval was one of the three short intervals (short category) or one of the three long intervals (long category).

There were four 20-min sessions, one for each of four possibilities: 2 directions (ascending/descending) X 2 base durations (mid-point: 160 or 320 ms). In the ascending condition, intervals were marked by one of three sequences: M-A, B-M, B-A; and in the descending condition, intervals were marked by one of three sequences: A-M, M-B, A-B. In the 160-ms base duration, short intervals lasted 100, 124, or 148 ms; and long intervals lasted 172, 196 or 220 ms. In the 320-ms base duration, short intervals lasted 200, 248, or 296 ms; and long intervals lasted 344, 392 or 440 ms.

Each session began with 18 practice trials (3 ascending conditions times 6 intervals). The experimental trials of a session were divided into three blocks of 72 trials (4 repetitions of 3x6 conditions). There was a 30-s pause between blocks.

The order of presentation of the two base duration conditions was balanced, with 12 participants beginning at 160 ms, and 12 at 320. Six of the 12 participants began with ascending trials, and six with descending trials.

Results

For each subject and each experimental condition, a 6-point psychometric function was traced, plotting the six comparison durations (from short to long) on the *x* axis and the probability of responding "long" on the *y* axis. The cumulative normal distribution was fitted to the resulting curves. The bisection point, BP, i.e., the point on the *x* axis where the probability of responding "long" is .50, was estimated for each experimental condition. The BP minus the base duration (160 or 320 ms) gives the constant error (CE). Note that a higher CE value indicated a shorter perceived duration (more "short" responses). Also, one SD on the psychometric function indicated the sensitivity for categorizing intervals as short or long. One (1) SD is commonly used to express sensitivity in time research (Grondin, in press; Killeen & Weiss, 1987; Ivry & Hazeltine, 1995).

Ascending trials

Mean CE are reported in Figure 1. Essentially, it shows, at both base durations, a higher CE in the B-A than in other conditions. The difference between the means of each condition was tested with a randomized block factorial Anova [2 (base duration) x 3 (B-M, B-A, M-A)] (Kirk, 1982). The Anova revealed a significant duration effect, $F(1,23)=6.99$, $\underline{p} < .05$, and a signal location effect, $F(2,46)= 6.72$, $\underline{p}<.01$. The interaction effect was not significant. The Tukey test showed that the B-A sequences were judged as being significantly shorter than the B-M or M-A sequences.

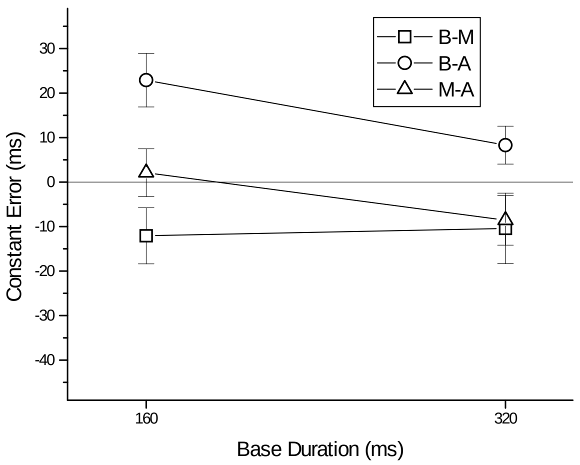

Figure 1. Mean Constant Error as a function of base duration for each marker type (location of markers: A=Above, M=Middle, B=Below) (Ascending trials)

Mean SD are reported in Figure 2, which shows, essentially, a higher threshold in the M-A condition at 160 ms, but a lower threshold in this same condition at 320 ms. The difference between the means of each condition was tested with a randomized block factorial Anova [2 (base duration) x 3 (B-M, B-A, M-A)]. The Anova revealed no significant main effect, and no significant interaction effect.

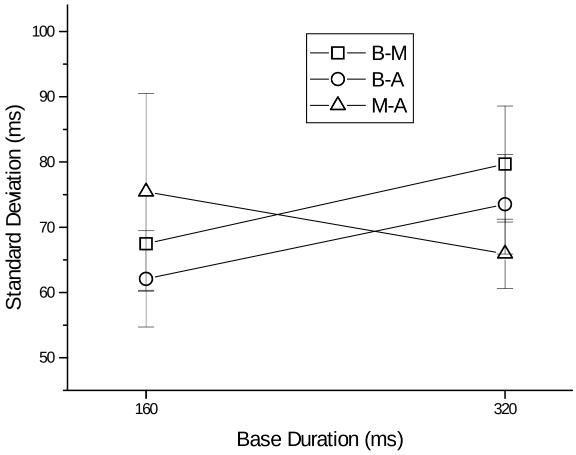

Figure 2. Mean Standard Deviation as a function of base duration for each marker type (location of markers: A=Above, M=Middle, B=Below) (Ascending trials)

Descending trials

Mean CE for the descending trials are reported in Figure 3. At both base durations, it clearly showed higher CE in the A-B than in other conditions. The Anova, according to the design described above [2 (base duration) x 3 (M-B, A-B, A-M)], revealed a significant duration effect, $F(1,23)=32.43$ $\underline{p} < .01$, and a signal location effect, $F(2, 46)= 15.14$, $\underline{p}<.01$. The interaction effect was not significant. The Tukey test showed that the A-B sequences are judged as being significantly shorter than the M-B or A-M sequences.

Mean SDs are reported in Figure 4. In both base durations, the SD in the M-B condition tended to be lower than the other conditions. The Anova [2 (base duration) x 3 (M-B, A-B, A-M)] revealed a significant duration effect, $F(1,23)=7.15$, $\underline{p}<.05$, and a significant marker location effect, $F(2,46)=6.08$, $\underline{p}<.01$, but the interaction effect was not significant. The Tukey test revealed better discrimination in the M-B than in the A-M condition.

Discussion

The CE results of each experiment's part clearly show that in the conditions used – one response after two signals, i.e. one interval – there is no longer perceived duration with more distance between the signals, as would be predicted from a generalization of a kappa effect. On contrary, in both ascending and descending parts, the results demonstrate that duration is perceived as being shorter signals were at a greater distance from one another. In this condition, it is not surprising that no result supports the second prediction, that regarding A-M vs. M-B or M-A vs. B-M. In short, the main factor involved in the experiment was not the relative height of signals, but the total distance.

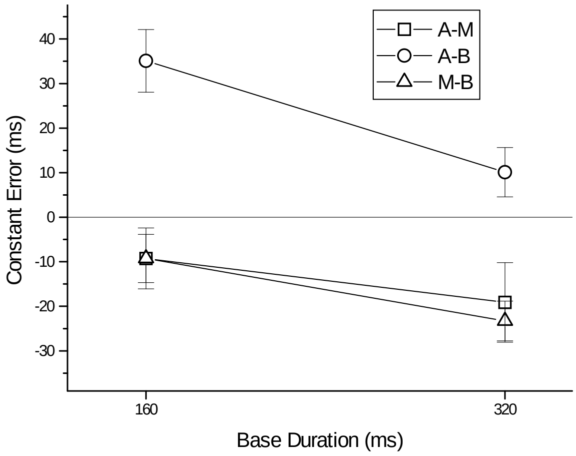

Figure 3. Mean Constant Error as a function of base duration for each marker type (location of markers: A=Above, M=Middle, B=Below) (Descending trials)

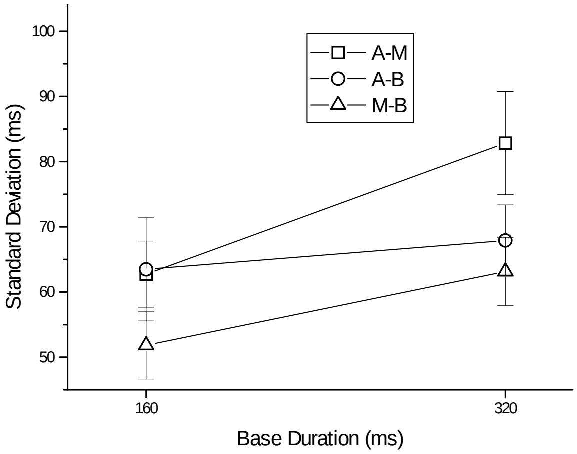

Figure 4. Mean Standard Deviation as a function of base duration for each marker type (location of markers: A=Above, M=Middle, B=Below) (Descending trials)

This distance effect can be accounted for on the basis of the internal-clock perspective described above. It is often assumed that a critical factor determining the accumulation of pulses in an internal-clock system is the fact of allocating or not attention to time, or the failure to do so (Grondin & Macar, 1992; Macar, Grondin & Casini, 1994). In this context, one interpretation of the present CE results is that a greater-distance condition would require a larger displacement of attention from one signal to the other. This switching process would divert away attention from time, diminishing the number of pulses accumulated during the interval to be timed.

On the other hand, this attentional interpretation encounters limits if SD results are considered. If attention is diverted away from time, lower performance (higher SD) should have been observed in the A-B or B-A conditions. In fact, however, neither ascending nor descending trials show such results.

REFERENCES

Grondin, S. (1993). Duration discrimination of empty and filled intervals marked by auditory and visual signals. Perception and Psychophysics, 54, 383-394.

Grondin, S. (2001). From physical time to the first and second moments of psychological time. Psychological Bulletin, 127, 22-44.

Grondin, S. (in press). Discriminating time intervals presented in sequences marked by visual signals. Perception and Psychophysics.

Grondin, S. & Macar, F. (1992). Dividing attention between temporal and nontemporal tasks: A performance operating characteristic -POC- analysis. In F. Macar, V. Pouthas & W. Friedman (Eds.), Time, Action, Cognition: Towards Bridging the Gap (pp. 119-128). Dordrecht, Netherlands: Kluwer.

Ivry, R. B. & Hazeltine, R. E. (1995). The perception and production of temporal intervals across a range of durations: Evidence for a common timing mechanism. Journal of Experimental Psychology: Human Perception and Performance, 21, 3-18.

Jones, B. & Huang, Y. L. (1982). Space-time dependencies in psychophysical judgment of extent and duration: Algebraic models of tau and kappa effects. Psychological Bulletin, 91, 128-142.

Killeen, P. R. & Weiss, N. A. (1987). Optimal timing and the Weber function. Psychological Review, 94, 455-468.

Kirk, R. E. (1982). Experimental design: Procedures for the behavioral sciences. Belmont, CA: Brooks/Cole.

Macar, F., Grondin, S., & Casini, L. (1994). Controlled attention sharing influences time estimation. Memory and Cognition, 22, 673-686.

Zakay, D., Block, R. A., & Tsal, Y. (1999). Prospective duration estimation and performance. In D. Gopher & A. Koriat (Eds.). Attention and Performance vol. XVII (Cognitive regulation of performance: Interaction of theory and application) (pp. 557-580). Cambridge, MA: The MIT Press.

Acknowledgments. This research was presented in partial fulfilment of the master's degree of IG under supervision of SG. The research was supported by a Grant from the Natural Sciences and Engineering Council of Canada to SG, and by an NSERC scholarship to IG.