# Estimated duration of an auditory signal as a function of its intensity

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*Estimates of time intervals ranging from 50 to 800 csec were made by 36 Ss. The intervals were presented as auditory signals of fixed (1000 cycle) frequency but of varying intensities (20 to 60 dB). Two methods of measuring the perceived duration were employed, a direct estimate in csec and a comparison of the test signal with one of fixed duration (200 csec) and intensity (40 dB). Perceived duration was found to be a positive function of signal intensity.*

The effect of the intensity of an auditory signal on the judgment of its duration has been investigated by Needham (1935), Oleron (1952), Steiner (1964), and Tanner, Patton, & Atkinson (1966). However, the results are not congruent. Needham's experiment with durations one to 6 sec showed that louder stimuli are overestimated and weaker ones underestimated; Oleron found that louder sounds were judged longer than softer sounds, but only in the case of very short durations. Steiner found that loudness level made a significant difference only for some relatively extreme comparisons (20 and 90 phons). Tanner et al dealing with durations .5 to 1.6 sec found no bias toward judging either 86 dB tones or 106 dB tones as longer.

The present study also investigates the hypothesis that increase in the level of signal intensity would lead to increased estimates of duration of auditory signals whose other characteristics remain constant. In this study, however, the dependent variable is measured by two different methods. This latter feature provides a convergence or methodological triangulation in assessing the effect of the experimental variable. Convergent measures were used because estimates of duration may be affected by the method of measurement (DuPreez, 1963; Fraisse, 1962, pp. 212-213; Gilliland & Humphreys, 1943; Siegman, 1962; and Warm, 1963).

**Subjects.** The Ss were 18 men and 18 women enrolled in introductory psychology courses at the University of Denver.

**Apparatus.** A Hewlett-Packard Model 200 Audio-Oscillator and an instantaneously gated electronic timer (built by the University of Denver Electrical Engineering Department) accurate to 1/1000 of the indicated interval were used to generate the signals. A preliminary recording was made to calibrate the equipment. The output of the signal generator corresponding to 20, 30, 40, 50, and 60 dB SPL (re .0002 dynes per $cm^2$) at 1000 cps was recorded on a Roberts 990 magnetic tape recorder at 7½ in. per sec, using one channel of the stereo head. The recorded signals were played back through the amplifier of the Roberts 990 and a pair of Roberts stereo earphones. The earphones enclosed a calibrated microphone whose output was shown on a direct reading dB meter so that the output level of the Roberts amplifier could be calibrated to correspond with the dB level of the signal generator. With the Roberts recorder so calibrated, the tapes actually used for the signal presentation were made.

Signal durations in the geometric series of 50, 100, 200, 400, and 800 csec were recorded at a constant 1000 cps frequency. Each signal duration was recorded at 20, 30, 40, 50, and 60 dB. The resulting 25 signals were recorded in random order with a blank intertrial duration of 700 csec. Three such recordings, each in a different random order, were made. In a second set of recordings each signal described above was preceded by a standard comparison signal of 200 csec duration, 1000 cps frequency and 40 dB intensity. The intersignal interval was 100 csec, and the intertrial was 700 csec in different random orders. Each tape began with three practice signals recorded at 1000 cps, 300, 500, and 700 csec at 1000 cps, 300, 500, and 700 csec at either 20, 40, or 60 dB, and presented in random orders.

**Table 1**
**Analysis of Variance for Direct Estimation of Duration**

| Source | df | MS | F |
|---|---|---|---|
| Duration (A) | 4 | 10,908,434 | 207.00*** |
| Intensity (B) | 4 | 129,006 | 11.46*** |
| Subjects (C) | 35 | 220,993 | 6.91*** |
| A x B | 16 | 30,241 | 4.05*** |
| A x C | 140 | 52,696 | 7.07*** |
| B x C | 140 | 11,257 | 1.51** |
| A x B x C | 560 | 7,455 | |

*Note. * for p < .05, ** for p < .01, *** for p < .001.*

**Table 2**
**Analysis of Variance for Comparison Estimation of Duration**

| Source | df | MS | F |
|---|---|---|---|
| Duration (A) | 4 | 3,225,144 | 112.36*** |
| Intensity (B) | 4 | 18,206 | 3.34** |
| Subjects (C) | 35 | 47,045 | 2.76*** |
| A x B | 16 | 4,819 | 1.79* |
| A x C | 140 | 28,703 | 10.68*** |
| B x C | 140 | 5,442 | 2.02** |
| A x B x C | 560 | 2,687 | |

*Note. * for p < .05, ** for p < .01, *** for p < .001.*

**Procedure.** The Roberts recorder and earphones were used to present the taped signals to S. Each S listened to only one of the first type of recording (direct estimation) and only one of the second type (comparison estimate). Each of the nine possible combinations of tapes (Method 1, No. 1, 2, or 3 paired with Method 2, No. 1, 2, or 3) was administered four times. Within each combination the order was counterbalanced over Ss, i.e., two Ss received direct estimation first and two Ss received comparison estimation first.

The instructions for the direct estimation required S to estimate the duration of the signals in "100ths of a second" and write his estimate on the record sheet provided. For the comparison judgment, S wrote his estimate of the duration of the test signal compared to the duration of the standard. The standard was described as being 100 units long; the test signal was to be estimated in the same kind of unit, i.e., some value smaller than 100 if shorter than the standard, 100 if equal, and a number greater than 100 if judged longer than the standard.

**Results.** Three-way analyses of variance (Walker & Lev, 1953, pp. 363-372) show the intensity main effect significant in both the direct estimation ($p < .001$) and the comparison procedure ($p < .01$). Duration, Ss, and the interactions were also significant (see Tables 1 and 2). Trend analyses of the treatment means (Edwards 1960, pp. 148-150) revealed a statistically significant linear regression for four of the five intervals for both estimation procedures (see Table 3). For each test signal duration, the regression of

**Table 3**
**Results of Trend Analyses Showing Significance of Linear Components for Means of Each of Five Test Durations Judged by Direct Estimation and Comparison Procedures**

| | | Linear | | |
|---|---|---|---|---|
| Method | Duration | df | F | P |
| Direct | 50 csec | 1/140 | 23.66 | .01 |
| Direct | 100 csec | 1/140 | 4.48 | .05 |
| Direct | 200 csec | 1/140 | 3.64 | NS |
| Direct | 400 csec | 1/140 | 16.05 | .01 |
| Direct | 800 csec | 1/140 | 23.97 | .01 |
| Comparison | 50 csec | 1/140 | 11.03 | .01 |
| Comparison | 100 csec | 1/140 | .97 | NS |
| Comparison | 200 csec | 1/140 | 6.61 | .05 |
| Comparison | 400 csec | 1/140 | 5.65 | .05 |
| Comparison | 800 csec | 1/140 | 5.33 | .05 |

**Table 4**
**Regression Coefficients and Their Standard Errors for Estimates of Duration on Signal Intensity**

| Test signal duration in centiseconds | Regression coefficient | Standard error |
|---|---|---|
| Direct estimation method: | | |
| 50 | .597 | .060 |
| 100 | 427 | .104 |
| 200 | .669 | .415 |
| 400 | 1.913 | .539 |
| 800 | 4.236 | .810 |
| Comparison estimation method: | | |
| 50 | .316 | .085 |
| 100 | .085 | .426 |
| 200 | 1.410 | .423 |
| 400 | .851 | .216 |
| 800 | 1.275 | .489 |

estimates of duration upon signal intensity was characterized by a positive slope (see Table 4).

**Discussion.** Results obtained using both methods of measurement, direct estimation and comparison judgments, confirmed the hypothesis that increasing levels of intensity would result in increased estimates of the test signal duration. A speculative basis for the effect of stimulus intensity on judgments of duration may be derived from the phenomenon of after-effect (Rosenblith, 1947). Hebb's theory of reverberating circuits which continue to fire subsequent to the removal of the stimulus which caused the initial excitation provides a general framework for such phenomena (Hebb, 1949). It seems possible that increased intensity of stimulation would result in more pronounced and longer lasting after-effects. The after-effect may be incorporated into S's estimate of the interval so that apparent duration is correlated with the intensity increase. An alternative explanation could postulate an "internal clock" which would be responsive to the level of energy input, and thus would record the passage of more time when the stimulus input is intense rather than weak. This latter conception could be extended to account for the studies which show that filled intervals (i.e., those during which the stimulus is continuously presented) are judged longer than empty intervals (Gavini, 1959; Goldfarb & Goldstone, 1963; Goldstone & Goldfarb, 1963; and Roelofs & Zeeman, 1949). Finally, the effect of intensity may be partly due to a more rapid perception of the onset of the more intense sounds. The inverse relation which has been found between reaction time and stimulus intensity (Woodworth & Schlossberg, 1954, p. 19) suggests the possibility of a similar intensity effect upon the time required to start the "internal clock."

The significant subject-effect and subject-by-duration interaction is in accordance with studies which show estimates of duration a function of personality variables (Campos, 1966; Meerloo, 1948; Zelkind & Spilka, 1965). Individual differences in reaction time (Woodworth & Schlossberg, 1954, pp. 27-39) could relate to the S by intensity interaction. Research in progress is exploring the duration by intensity interaction as well as the effect of method on estimates of duration.

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## NOTE

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