Magnitude estimation of loudness with a minimum 24-h interstimulus interval*

BRUCE A. SCHNEIDER

Columbia University, New York, N.Y. 10027

ALLEN J. NEURINGER

Reed College, Portland, Oreg. 97202

and

DOUGLAS RAMSEY

Foundation for Research on the Nervous System

36 The Fenway, Boston, Mass. 02215

Magnitude estimates of the loudness of white noise were obtained in two conditions: in the first, the time between consecutive stimulus presentations was at least 24 h; in the second, the time was less than 2 min. In both conditions, the relationship between the reports of the Ss and the intensities of the stimuli was best described by a power function. The exponent of the function was lower and the variance was slightly greater in the 24-h interstimulus condition.

The technique of magnitude estimation, originally developed to study sensory magnitude (Stevens, 1962) has been used to study the psychological magnitude of social events such as the esthetic value of music, the importance of different monarchs, and the seriousness of crimes (Stevens, 1966). The general utility of magnitude estimation in these and other cases has prompted several investigations of basic parameters of the technique such as stimulus spacing and standard vs no standard stimulus. One parameter which has received relatively little attention is the time interval between stimulus presentations. It is sometimes difficult to control this interval, especially when the object of study lies outside of the laboratory. For example, many phenomena, such as soundness of sleep, quality of air, goodness of feeling, or excellence of performance, have, of necessity, long intervals between stimulus presentations. The present study investigates the effects of prolonged interstimulus intervals on the form of the function relating loudness to the sound pressure level of white noise. Loudness estimates obtained with at least 24-h interstimulus intervals are compared to those obtained with less than 2-min intervals.

SUBJECTS

Twenty-four male and female high school students who were participating in a National Science Foundation summer program at the Foundation for Research on the Nervous System served as Ss. All Ss reported normal hearing at the beginning of the experiment and were divided

randomly into two equal groups. Two of the 24 Ss (both from Group 1) failed to complete the experiment, and their data are not included. None of the Ss had any previous experience with any form of psychophysical scaling. All were cautioned not to discuss the experiment with each other until it was completed.

APPARATUS AND STIMULI

The white noise was generated by a Grason-Stadler 901A noise generator and led through a 4- to 600-ohm transformer to a 2-dB-per-step Daven attenuator. The output of the attenuator drove a Koss Pro-600A earphone. The voltage drop across the earphone was monitored with a calibrated Ballantine VTVM. Seven intensities of white noise, varying in 8-dB steps over a 48-dB range, were presented. The lowest noise level was selected to be clearly audible. All seven intensity levels were judged by the Es to be in a comfortable listening range. Since no calibrations of the white noise source and earphone were available, the intensity levels are specified in relative units. Listening, which was monaural (right ear), took place in an open room in which S and E were separated by a partition. The attenuator setting was changed after each stimulus presentation, even when no change in level was programmed.

PROCEDURE

At the beginning of the experiment, the 24 Ss were divided randomly into two groups. The Group 1 Ss were presented with one noise stimulus per day. These Ss were required to assign numbers to represent the loudness ratios among the noise stimuli. No standard was employed, and the following instructions were read to the S.

"This is an experiment to see how you perceive the loudness of sounds. When the experiment begins, you will hear a sound. Assign a number to this

sound that you think best represents its loudness. You will then be presented with a series of sounds. You are to assign numbers to these sounds so that the numbers represent the loudness of the sounds. For examples, if one sound appears to be twice as loud as another, the numbers assigned to these sounds should stand in a 2 to 1 ratio. This means that if the softer sound was called 15 then the louder sound should be called 30, since it seems twice as loud to you. If, on the other hand, a sound appears to be only one-quarter as loud as a sound called 2, it should be assigned the number .5 or $\frac{1}{2}$. If the sound seems 10 times as loud as a sound called 20, you would assign it the number 200.

"Do you have any question?"

Stimulus duration was controlled by the S, using a two-position switch. Each of seven intensities was presented in a random order and then repeated (with a different order) twice more. Thus, S experienced 21 stimuli presentations, one per day. After completing the 21-day sequence, the experiment was repeated, only this time S experienced all 21 presentations within a single session. The time between stimulus presentations depended upon the response latency of the S, but was generally less than 2 min. Hence, Group 1 experienced two conditions in the following order: (1) spaced stimulus presentation with a minimum 24-h interstimulus interval, and (2) massed stimulus presentation with a less than 2-min interstimulus interval. The Group 2 Ss also experienced the same conditions, but in the reverse order; i.e., the massed stimulus presentations were followed by the spaced stimulus presentations. All other experimental parameters were identical for the two groups. For both groups and both conditions, the first seven stimulus presentations were omitted to exclude atypical measures of variability due to the first exposure to the stimuli. One S in the massed condition for Group 2 was erroneously presented the second highest level four times, while the highest level was presented only twice. Hence, in the Group 2 massed condition, the data are based on 23 and 25 estimates for the second highest and highest levels, respectively. In all other cases, the data presented below are based on 2 estimates of each seven intensity levels per S.

In the spaced condition, it was not possible to require the Ss to appear every day. Consequently, the 24-h interstimulus interval represents a minimum. The Ss usually were not present on the weekends and were absent for 4 days over the July 4th weekend. On one day, during the spaced condition for both groups, a

*This research was partly supported by Grant MH-15495-01 from the National Institute of Mental Health, by I.S.R.P. funds from Columbia University, and by National Science Foundation Institutional Grants funds from Reed College. Reprints may be obtained from B. Schneider, Psychology Department, Columbia University, New York, N.Y. 10027.

Fig. 1. Magnitude estimates of the loudness of a noise as a function of relative sound pressure in decibels for spaced (≥ 24 h) vs massed (≤ 2 min) interstimulus intervals for each of two groups. Each unit along the abscissa corresponds to a 16-dB change in sound pressure.

substitute E required 16 Ss to wear the earphone on the wrong ear. These data are included in the analysis. Any error committed by including these data is likely to be quite small and is distributed randomly over stimulus presentations and groups.

RESULTS

Figure 1 shows how magnitude estimates of loudness varied as a function of sound pressure level in log-log coordinates for both groups under the massed and spaced stimulus presentations. Straight lines have been fitted to the data points by the method of least squares. A straight line function in these coordinates indicates a power function relationship between the magnitude estimates and stimulus intensity. Figure 1 shows that, in all cases, a power function closely describes the growth of loudness. The exponent of the power function is given next to each line. The exponents for the spaced stimulus presentations for both groups are somewhat lower than those for the massed presentations. For Group 1, a two-tailed t test of the difference in slopes (Kendall & Stuart, 1967)

between massed and spaced trials was just barely significant at the $p = .05$ level. For Group 2, the value of t was just short of that required for the $p = .05$ level. These two tests, taken together, suggest that there is a slight but possibly significant difference in slope for massed vs spaced presentations. Furthermore, the function for the spaced presentations for the Group 1 Ss appears to exhibit a slight downward concavity.

Figure 2 shows how the standard deviation of the log magnitude estimates changed as a function of stimulus intensity. Since no standard was employed, the estimates were first normalized so that the mean log estimate for each S equaled 0. Then the standard deviations of the normalized log estimates at each of the seven intensity levels were obtained. This procedure corrects for the tendency of different observers to employ different "internal standards" and therefore should reflect the inherent variability in the estimation process. Figure 2 shows that the standard deviation of the log estimates tends to decrease and then level off as stimulus intensity increases. For the Group 2 Ss, the standard deviation is always higher in the spaced stimulus condition. A sign test for matched pairs indicates that this difference is significant at the $p = .05$ level. However, no clear effect can be detected in the Group 1 Ss: the standard deviation is higher in four of seven cases for the spaced as compared to the massed stimulus conditions.

Fig. 2. Standard deviation of the normalized log magnitude estimates as a function of relative sound pressure for two groups experiencing massed vs spaced stimulus presentations. Each unit along the abscissa corresponds to an 8-dB change in sound pressure.

DISCUSSION

Figure 1 indicates that the technique of magnitude estimation may be fruitfully extended to situations in which the interstimulus intervals are not under E control and are considerably longer than the intervals typically used in

psychophysical studies. The use of long interstimulus intervals appears to result in a decrease in the obtained value of the exponent and a slight increase in variability. However, these effects might partly be a function of the use of experimentally naive Ss in the present work.

REFERENCES

- KENDALL, M. G., & STUART, A. *The advanced theory of statistics*. New York: Hafner, 1967. Pp. 371-372.
- STEVENS, S. S. The surprising simplicity of sensory metrics. *American Psychologist*, 1962, 17, 29-39.
- STEVENS, S. S. A metric for the social consensus. *Science*, 1966, 151, 530-541.