Tapping the social psychology of psychophysical experiments: Mode of responding does not alter statistical properties of magnitude estimates

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In an attempt to measure how mode of response might affect psychophysical judgment, 18 sub-jects were asked to give magnitude estimates of the loudness of 1000-Hz tones at various sound pressure levels in each of two sessions. In one session, the subjects responded by giving their numerical judgments orally to the experimenter; in the other session, they did so by entering their judgments manually on a computer-controlled keyboard. Mode of response had no effect on the loudness function's log-log slope and a small, statistically unreliable, effect on the function's intercept.

An increasing number of psychophysical scaling studies use a fully automatic, computer-driven apparatus that requires subjects to enter their numerical responses directly on a keyboard rather than to communicate them orally to a recording experimenter. Despite the considerable resulting change in social interaction, possible effects of the new mode of responding have gone largely untested in current psychophysical research. Results of the present study, which contrasted traditional (voice) and new (key-board) modes of responding, show that the resulting mag-nitude estimates remain largely, though perhaps not fully, unchanged across the procedural variation in responding.

The study of psychophysics relies as much on techno-logical innovation as it does on substantive empirical find-ings and theoretical development. Ingenuity in producing and controlling stimuli restricts the set of possible attain-able results. Indeed, the history of psychophysics parallels that of the instrumentation used to produce the various stimuli in sensory experiments. For example, the study of loudness, pitch, and other psychoacoustic phenomena has progressed at a pace with the technical mastery to pro-duce an ever-increasing repertoire of auditory signals (e.g., complex spectra, extremely short durations). However, recent developments in instrumentation—in particular, the pervasive use of computers in psychophysical research—justify examining any possible effects of such develop-ments on responses. Computers, for instance, are used not just to produce stimuli and process data but also to directly record responses. What might be the outcome of substituting the computer for the experimenter in psycho-physical research?

Of the many direct scaling methods in psychophysics, one of the most popular is magnitude estimation. Since its development in 1954, this method has been used in numerous applications in virtually all perceptual domains (see Gescheider, 1985, for a comprehensive summary). In addition to yielding scales of sensory magnitude, mag-nitude estimation can also be employed to generate equal-sensation contours and to generate judgments in mixed-modality scaling. For more than three decades, magnitude estimation has served to elucidate processes of cognition and judgment as well as sensory and perceptual function-ing. Its versatility for model construction, coupled with the ease of its application, has helped to make magnitude estimation one of the most widely used psychophysical methods. Much of present-day psychophysics relies on results obtained using magnitude estimation.

However, the traditional method of magnitude estima-tion that served so valuably in producing a rich set of fun-damental results differs in one important aspect from the way in which the method is applied in an increasing num-ber of current studies. During the first two decades of its use, in many instances magnitude estimation involved ac-tively communicating experimenters who recorded sub-jects' orally given numerical responses. As in many inter-active psychological experiments, there was a possibility that unintentional, covert cues might be given by ex-perimenters. In contrast, in a growing number of modern computer-controlled studies, subjects type in their mag-nitude estimates and may control the rate of stimulus presentation as well as the recording of their responses. Subjects no longer interact with an experimenter during the experimental session; in most cases, no experimenter is needed. Does the change in procedure—typing the nu-merical estimates in solitude rather than communicating them orally to an attentive experimenter—effect changes in the resulting estimates? The question is important be-cause if it is answered in the affirmative, we will be com-pelled to add yet another member to the already large set of conditions affecting judgments derived in direct scal-ing procedures.

Despite the obvious change wrought by the computer revolution on social interaction in psychophysical experiments, we find no study that attempts to gauge how mode of responding might affect scaling data. Consequently, the present study addresses this issue directly by having subjects, in alternate sessions, respond orally or type in their responses to the same array of auditory stimuli.

METHOD

Subjects

Eighteen young men and women from Yale University participated in two experimental sessions conducted at least 1 day apart. None of the subjects reported a history of hearing problems, and we assumed that all had normal hearing. The subjects were paid $5 per session.

Apparatus and Procedure

The stimuli consisted of 1-sec bursts of a 1000-Hz tone, with 10-msec rise and decay, presented monaurally to the right ear through TDH-35 headphones mounted in MX41/AR cushions. Stimuli were generated by Coulbourn Instruments modules under the control of an Apple IIe microcomputer. The tones took on 10 different sound pressure levels (40-85 dB SPL in steps of 5 dB), each presented and judged a total of 10 times within the course of a session.

Each subject served in two sessions. In one they entered the responses on a keyboard, and in the other they communicated their judgments orally to an experimenter located outside the sound-isolated booth. Within a session, order of stimulus levels was random and different for every subject, with order of sessions (i.e., mode of responding) counterbalanced randomly across subjects.

The method was magnitude estimation with no specified modulus. The subjects were instructed to assign to the first stimulus whatever number they deemed appropriate to stand for its loudness, then to assign to succeeding stimuli other numbers in proportion. Whole numbers, decimals, and fractions were permitted. The number zero could reflect the absence of a sound, but it was never reported.

RESULTS AND DISCUSSION

In both response conditions, the magnitude estimates given by each subject to each stimulus were averaged geo-metrically (within sessions), and simple power functions were fitted to the relation between mean estimates and sound pressure level. Table 1 lists, for each subject, parameters of the power functions as well as other measures of performance in each condition.

The data show virtually no effect of mode of responding on performance. There was no effect on the exponent of the power function [$t(17) = 1.02, p > .3$]. The voice condition provided a slightly, but insignificantly, greater intercept [$t(17) = 1.54, p > .1$]. Nor is there any discernible difference in the measures of goodness of fit (r^2 values) of the individual power functions under the two modes of responding. Clearly, having subjects enter their estimates manually onto a computer-controlled keyboard instead of communicating their judgments orally effected no significant changes in the parameters of the power functions.

We performed several other analyses of the data, but we found no evidence that mode of responding made a difference. Order of sessions mattered little to the derived exponent (a change of a mere 0.002), but there was an insignificant voice-first-keyboard-first difference of 0.19 in intercept. No significant differences were found in either the overall magnitude of the judgments [$t(17) = 0.85, p > .3$] or in the respective coefficients of variation between the two conditions [$t(17) = 1.28, p > .2$], although again we see the slight evidence of greater numerical estimates under the voice condition. This tendency becomes even more visible when we pool data over subjects and plot the group means (see Figure 1).

Although the difference in absolute levels is not significant, the vertical separation of the curves in Figure 1 clearly warrants further attention. Given the widespread fitting of power functions as a major analytical tool of data reduction in psychophysics, investigators may well wish to examine possible influences on the intercept. For

Table 1
Parameters of Power Function Approximations, Goodness of Fit Measures, Means, and Coefficients of Variation under the Voice and Keyboard Responding Conditions, Individually for 18 Subjects

S	Voice						Keyboard					
	a	b	r^2	A.M.	G.M.	C.V.	a	b	r^2	A.M.	G.M.	C.V.
1	−.23	.46	.990	20.9	15.9	.21	.75	.41	.978	4.4	3.5	.22
2	.16	.34	.952	19.4	16.4	.28	.14	.35	.967	20.4	17.0	.28
3	−.81	.68	.990	34.3	20.0	.28	−.70	.65	.977	34.5	20.8	.45
4	−.18	.37	.951	11.1	9.1	.36	−.65	.44	.961	6.9	5.3	.45
5	−.88	.46	.946	6.1	5.2	.22	−.68	.32	.981	4.8	3.7	.31
6	−.68	.32	.981	5.9	4.5	.47	−.72	.33	.982	4.7	3.6	.22
7	.23	.32	.946	20.3	17.4	.18	−.05	.42	.965	23.4	18.2	.27
8	−.68	.32	.981	2.5	2.2	.26	−.72	.33	.982	2.3	2.0	.18
9	−.41	.32	.988	4.5	3.9	.19	−.66	.38	.992	3.9	3.3	.22
10	−.20	.69	.974	149.8	88.0	.36	−.20	.70	.950	160.8	94.6	.33
11	−.48	.37	.947	6.0	6.1	.32	−.63	.48	.976	5.3	4.2	.31
12	−.68	.46	.963	8.2	5.9	.32	−.52	.44	.996	9.1	7.1	.35
13	−.98	.41	.961	24.0	18.9	.32	.13	.39	.982	27.6	22.6	.33
14	.25	.40	.990	38.0	31.1	.21	.15	.39	.994	29.4	24.0	.26
15	−1.00	.47	.953	13.4	11.8	.22	−.90	.44	.971	9.1	7.4	.30
16	.79	.20	.917	41.4	31.9	.33	1.10	.21	.922	38.3	30.1	.44
17	−1.00	.47	.953	3.9	3.0	.19	−.90	.44	.971	3.9	3.0	.19
18	.23	.20	.956	7.4	6.9	.12	−.04	.28	.971	7.9	7.1	.22

Note—S = subject, a = intercept of power function, b = exponent of power function, r^2 = goodness of fit, A.M. = arithmetic average of magnitude estimates, G.M. = geometric average of magnitude estimates, C.V. = median coefficient of variation of magnitude estimates.
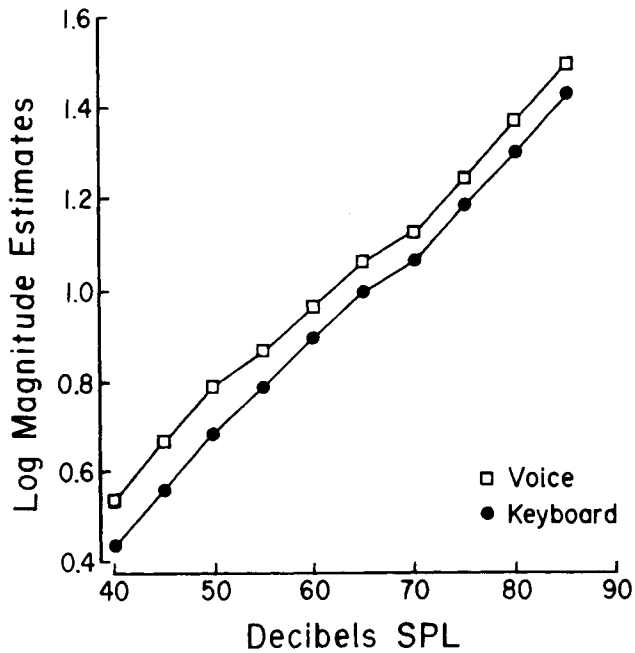
Figure 1. Average loudness functions for voice and keyboard modes of responding.

example, some theories, notably that of Zwislocki (1983; see also Zwislocki & Goodman, 1980), postulate an "absolute" coupling between stimulus intensities and individual numerical responses. Inferences about absolute scaling may require modification should the sizes of the numbers depend on the mode of responding.

In summary, this study sought to provide comparative data on the way that two widely used methods of responding might influence the statistical properties of magnitude estimates. The results of the present experiment provide some badly needed preliminary evidence that the increased use of subject-controlled direct feeding of data does not alter to any substantial degree the important properties of those data. This may provide some relief for investigators who use fully automated, computer-driven experiments in which subjects generate magnitude estimates.

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