Discrimination of hefted weights: Effect of stimulus duration

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Abstract

In an experiment with hefted weights, Ss discriminated between 500 and 540 gm or between 500 and 560 gm. Each of these discriminations was studied with stimulus durations ranging from 100 to 1600 msec. Discriminability increases over the range 100 to 400 msec. and seems to have reached a plateau between 400 and 800 msec. An apparatus is described for controlling stimulus duration in psychophysical studies of weight discrimination.

Problem

The study of psychophysics began in the early 19th century with the experiments of E. H. Weber on the ability of humans to discriminate between hefted objects of differing weight. Since that time most studies of hefted weight have concentrated on the methodologies by which data may best be collected (Helson, 1964). With few noteworthy exceptions (Payne & Davis, 1940; Oberlin, 1936) most investigators have ignored the sensory factors which actually limit discriminability and as a result such factors remain little understood. One hitherto unexplored factor which seems likely to control discrimination is the duration for which the weight is hefted. Although temporal characteristics of weight discriminability are interesting in their own right, the relationships between them and other determinants of weight discriminability may permit the definition of the as yet unknown receptive system underlying the perception of heaviness. This report will describe an apparatus for providing precise control of heft duration and other pertinent variables and will present results of a preliminary experiment making use of it.

Method

Basically, the apparatus is a 125 cm long aluminum lever with the pivot 55 cm from one end and a handle 30 cm from the other. The handle protrudes through an opaque screen which shields the rest of the apparatus from the S's view. A counterweight on the shorter section of the lever can be adjusted to yield an effective downward force at the handle of from 0 to 2000 gm. After the counterweight is set, different increments can be added by energizing one of a series of electromagnets positioned beneath the lever between the pivot and the handle. These electromagnets are spaced so that each one will increment the weight of the lever by 10 gm more than does its neighbor nearer the pivot. The energized electromagnet attaches itself to a thin steel strip on the lever and rides with it. This method of generating different weight values permits more rapid changing of stimuli and shorter intertrial

intervals than previously possible. Because the increments are controlled electrically the apparatus also lends itself to automatic programming of stimuli.

In the current arrangement, the experimenter selects 2 from the bank of 10 incremental magnets for use in a block of trials. Specially designed programming circuits then determine which of the two magnets will be activated on any trial. In the experiment to be reported the light stimulus state was always 500 gm. The heavy stimulus was either 540 or 560 gm, depending upon the session. The S's task was to judge, after he had lifted the lever, whether the heavy or the light stimulus had been presented. Judgments were indicated by moving to one side or the other a spring loaded toggle switch with the left hand. If the judgment was correct (e.g., S judged the 500 gm weight as light), a light immediately signaled response correctness.

A programming circuit controls stimulus values, duration of lift, intertrial interval, and provides temporary storage and display of the stimulus values and the S's response for each trial. The sequence of events during the trial was the following. First, a "ready" light came on over the handle signaling the start of the trial. The S then lifted the handle activating an interval timer which controlled the time for which the weight was available to the S. At the end of the chosen stimulus duration an electromagnetic brake locked the lever in whatever position it happened to be. The S closed a response switch to indicate his judgment of which stimulus had been presented and this de-energized the incremental electromagnet and activated the intertrial interval timer. One-half sec. before the signal for the next trial the brake released and the lever dropped to its rest position. An auxiliary electromagnetic brake cushioned the fall of the lever and held it in rest position while the next increment was activated and attached to the lever. In addition to controlling temporal variables, the apparatus also had an adjustable stop which limited the extent of lift to 1.5 cm.²

The S sat in a modified dental chair with his right forearm supported by the arm of the chair and the heel of his hand on the table in front of the handle. With the fingers of the right hand loosely flexed, the handle rested just above the distal joint of the index finger. The handle could be lifted by rolling the right hand across the heel or by raising the hand off the table. In either case it was not necessary to move the forearm and all Ss adopted a simple wrist motion for the lift.

Fig. 1. Discrimination of lifted weights as a function of stimulus duration. (a) Performance of individual subjects in discriminating between 500 and 540 gm. (b) Performance of individual subjects in discriminating between 500 and 560 gm. (c) Group curves for each of the two discriminations.

Seven male Ss served in two practice and six experimental sessions lasting about 45 min. and separated by at least 24 hr. In each session the light weight (500 gm) and one of the heavy weights (540 or 560 gm) was presented with approximately equal frequency according to a random sequence. The use of 540 or 560 gm as the heavy stimulus varied between sessions in a quasi-random order. Within any session five blocks of 100 trials were run, one with each of five stimulus durations: 100, 200, 400, 800, and 1600 msec. The order of these durations within a session was random. The intertrial interval was 1.5 sec.

Results and Discussion

The results of the experiment are shown in Fig. 1a-c. The mean value of per cent correct responses for each S and stimulus duration is shown in Fig. 1a for the discrimination between 500 and 540 gm; results for the discrimination between 500 and 560 gm are shown in Fig. 1b. Figure 1c shows the group means for both discrimination at each stimulus duration (each point is based on 2100 trials). An analysis of variance was done to verify the picture given by Fig. 1-c. The analysis showed only two significant effects. These were the duration of the stimulus, $F(4,24) = 15.23$, $p < .001$, and whether the discrimination was between 500-540 or 500-560 gm, $F(1,6) = 39.82$, $p < .001$. No other term approached significance. The

data indicate that the discriminability of hefted weights is strongly affected by the duration for which the weight is available to the S. With both pairs of stimuli used, discriminability increases over the range 100 to 400 msec. and seems to reach a plateau in the interval between 400 and 800 msec. It was expected that with the longer stimulus durations the S might become adapted to the weight he was lifting and it would tend to feel lighter as the lift progressed. We expected that this adaptation might show up as a systematic change in response bias with increasing stimulus duration. According to this notion, Ss would make more incorrect "light" judgments at long durations than at the short. To equate for absolute level of discriminability the following statistic was used: a ratio between the frequencies of incorrect "light" and incorrect "heavy" judgments. Contrary to expectations, there did not prove to be any systematic change in this ratio with stimulus duration. It may have been the case that the stimulus durations were not of sufficient length to produce adaptation. An alternative explanation is that Ss, knowing that the two stimulus states would occur with equal frequency, divided trials on which they felt uncertain between "heavy" and "light" responses.

Once precise control over the nominal stimulus is obtained there is a tendency to forget that Ss may not be passive recipients of that stimulus. In a related context, Gibson (1962) has argued that "experimenters have not realized that to apply a stimulus is not the same as for an observer to obtain a stimulus." Observations of our Ss' behavior suggested that they were engaged in a highly active process of "obtaining" a stimulus. When permitted by stimulus duration, Ss tended to follow the initial lift of the bar with smaller, secondary oscillatory movements. These secondary adjustments may represent the output of a feedback system designed to optimize the discriminability of lifted weights and their contribution is currently being studied in our laboratory in a servo-analytic framework.

References

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Notes

1. Now at Northwestern University, Evanston, Illinois. This research was carried out during the tenure of a Public Health Service Postdoctoral Fellowship for R. W. Sekuler. Part of this work was performed at the M. I. T. computation center.
2. Subjects rarely lifted the handle the entire permitted distance; typical excursions were of the order of 1.0 cm. Preliminary observations suggest that the extent of the lift may be a variable of considerable importance.