A COMPARISON OF TWO PSYCHOPHYSICAL METHODS USING ANIMALS¹

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A discrimination box containing two levers with a light above each was used to train eight rats to press beneath the brighter light for a milk reinforcer. The brighter light was held constant and the comparison light was varied to produce 12 brightness differences. The animals were run under two experimental methods: the block method in which each brightness level comparison was presented for a block of 11 contiguous trials, and the staircase method in which the sequence of brightness comparisons was determined by the correctness of the response on the preceding comparison. The block method produced a smaller differential brightness threshold and a larger change in discrimination performance for stimulus magnitude changes than did the staircase method.

Animals are being more frequently used as subjects in the study of psychophysical functions. Unfortunately, there is a dearth of literature comparing the influence on animals' performance of one rather than another psychophysical method. This limits the ability to select an appropriate experimental technique.

Comparative investigations have been performed for psychophysical techniques using human subjects. One of the most thorough is contained in a monograph by Blackwell (1953). After measuring thresholds and variability of responses using several psychophysical methods, Blackwell concluded that stimulus comparisons presented in blocks, rather than in random sequence, produces lower thresholds and decreases variability.

The present study compared two psychophysical methods used to determine a differential brightness threshold in rats. One was the block method which Blackwell reported superior to the random method. In the block method used in this study, the animals were presented with successive blocks of 11 trials under each pair of stimulus comparisons used.

The second method examined was suggested by the animal testing technique utilized by Blough (1958) based on the work of von Bekesy (1947). In the present version, hereafter called the staircase method, one of the two stimuli to be compared varied from trial to trial in an order determined by the animal's ability to respond correctly on the preceding trial. If the animal correctly selected the brighter of two lights, the response was reinforced. The next comparison trial presented the more difficult task of choosing between lights closer in luminance. If the dimmer light was selected, the next trial presented a less difficult discrimination task between lights with greater luminance difference.

The staircase method was compared with the block method because it is uniquely able to give almost continuous threshold values over time and is therefore useful in studying variables which might have transient effects.

METHOD

Subjects

Eight male Sprague-Dawley rats from the UCLA medical school colony, 8 to 10 weeks old at the beginning of the study, were used.

Apparatus

The rats were run in a two-choice discrimination box, roughly in the form of a V. The floor plan is shown in Fig. 1. At the broad end of the box were two levers separated by a

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Fig. 1. Floor plan of the discrimination box.

divider, 8 in. in length. The divider had a 2-in. square hole where it was attached to the wall. The feeding receptacle for the milk reinforcement was mounted in the hole and was accessible from both sides. Above each lever was a $1\frac{1}{4}$ in. diameter hole containing an electroluminescent panel. These panels emitted a green light.

At the base of the V, a small bulb illuminated a photoelectrical cell controlling a relay. To minimize light reflection, the walls and divider were painted flat black. The top was constructed of clear plastic. This discrimination box was placed within a larger box to control extraneous light and sound. A fan-driven air supply produced masking noise. A one-way window in the top of the larger box permitted the performing subject to be observed. Stimulus conditions and responses were recorded by a 20-pen event recorder. All experimental contingencies were programmed automatically by relay switching circuits.

The enclosures and programming equipment were contained in an interior room. To ensure adequate and consistent levels of dark adaptation throughout the experiment, the animals were brought into the darkened experimental room 30 min before the first subject was run. The room remained dark until the last animal had completed its run. The only light sources were the small neon bulbs

on the relay racks and the bulb illuminating the photoelectric cell.

Procedure

When the rat was initially placed in the discrimination box at the narrow end of the V, the photoelectric relay was activated, which lit the two panels on the opposite wall. One panel was lit at a standard luminance level, the other at a comparison level. If the rat pressed the bar under the brighter of the two lights, which was always at the standard level, a reinforcement of 0.05 cc of a 50 per cent diluted solution of sweetened condensed milk was delivered to the receptacle in the divider wall. If the bar under the dimmer of the two lights was pressed, no reinforcement was delivered. A non-correction method was used. Pressing either of the two bars extinguished both light panels. Resetting the lights for another trial required the rat to return to the narrow end of the V to again break the light path to the photoelectric cell relay. The constant standard luminance level was paired with each of 12 comparison luminance levels. The position of the standard and comparison lights was alternated from side to side to prevent side or alternation biases. (Hilgard, 1951)

The standard stimulus was at a luminance level of 10.1 foot-lamberts. The 12 comparison steps began with a level of 1.6 foot-lamberts for step one. This was followed with foot-lambert readings of 2.2, 2.6, 3.5, 3.9, 4.6, 4.9, 5.7, 6.7, 8.1, and 9.6 for the succeeding steps, ending with 10.1 for step 12. Luminance measures were taken with a Spectra Brightness Spot Meter.

Luminance steps were selected on the basis of a pilot study where they produced approximately equal increments in per cent-correct performance by newly trained rats. For rats with additional training, these step values no longer produced equal performance increments. Nevertheless, the same steps were maintained throughout rather than introducing another experimental variable by changing step values after the initial training.

The most difficult comparison luminance, step 12, was at the same luminance level as the standard stimulus. This comparison level serves as a control over the procedure and apparatus because 50 per cent of the responses should occur to the standard light regardless of the subject's skill. At this comparison

level, responses to the standard light were arbitrarily scored as correct and thus reinforced.

At the beginning of training, the rats were reduced to 80 per cent of usual body weight. Throughout the experiment proper, they were 23 hr food deprived at the time of their daily runs. After daily sessions were completed the animals received 10 g of dry lab chow. This maintained them at a stable weight with only small variations. Water was freely available in the home cages.

For both methods, stimulus programming was similar in that the same standard and comparison brightness steps were used, and the alternation pattern of stimulus presentation was the same.

Staircase Method

In this method, programming of the comparison light was controlled by the rat's performance. Each bar press under the brighter light (the reinforced response) was followed on the next trial by the next more difficult comparison. Each bar press under the dimmer light (the unreinforced response) was followed on the next trial by the next easier comparison.

Block Method

This method differed from the staircase method in that the experimenter controlled the programming of the discrimination task, *i.e.*, the luminance level of the comparison stimulus. Comparisons at a given discrimination step were made in blocks of 11 trials rather than varying the discrimination task with each trial as in the staircase method. Again, only responses to the brighter light were reinforced.

Limitations in the programming equipment, made it impossible to record the results of the eleventh trial in each block. Therefore, the data reported for the block method include only the number of correct responses for the first 10 of the actual block of 11 trials.

The animals were run daily during training for 264 trials. Each of the 12 comparison steps was examined twice in blocks of 11 trials. The day's trials would typically begin at step 1 for a block of 11 trials, then progress consecutively through the steps to step 12. At step 12, the process would be repeated in reverse order with trial blocks until the animal returned to step 1.

A sequence of comparison steps which begins at step 12 and moves towards step 1 is called the "descending order"; a sequence beginning at step 1 and moving towards step 12 is the "ascending order".

Step 12 is the comparison stimulus level with the smallest brightness difference from the standard and is therefore the most difficult comparison. Step 1 has the greatest brightness difference from the standard and is the easiest comparison.

Training and Data Collection

The data presented were obtained after performance stabilized. Initial training to press the bar under the brighter of the two lights, and then to reset the lights by returning to the opposite end of the enclosure, typically required 10 half-hour sessions.

Training on the staircase method was completed and data collected before training on the block method was begun. During training and data collection on the staircase method, the animals were permitted 140 trials a day. Training was continued until the mean performance curve for all eight animals averaged less than 2-per cent change in per cent-correct from day to day. At that point, data were compiled for four successive days for comparison with block method data.

After the staircase method data were collected, training began on the block method. Initially, all rats were run either from step 1 to 12, the ascending order, followed by steps 12 to 1, the descending order, or in the opposite set of sequences. Because this resulted in 264 trials, performance was slow towards the end of a session. In addition, the rats were already at such a high level of performance that they achieved 100 per cent performance on steps 1 through 5 except for a rare single error. Therefore, the apparatus was modified so that only steps 6 through 12 were utilized for comparisons with the standard luminance level. To prevent a warm-up effect from confounding the influences of different sequences, the session began with a block of trials on step 6, now the easiest step.

A stable level of performance appeared almost immediately for these already well-trained animals. The animals were run for 25 days and the data from the last eight days were used.

During these eight days, various sequences

of blocks were used to investigate the influence of the sequence. They included the following: (1) steps 6 to 12, followed by 12 to 6; (2) step 6, 12 to 6, 6 to 12; (3) step 6, 10 to 12, 12 to 10, 10 to 12; and (4) step 6, 12 to 10, 10 to 12, 12 to 10.

Finally, to determine the possible influence of further practice upon the comparison between the block and staircase methods, the animals were again run under the staircase method for two additional weeks after the block method was completed. The results of the last eight days were averaged.

RESULTS

Figure 2 contains three curves showing the proportion of correct responses at comparison levels 6 through 12 for the two sets of days of staircase method trials and the one set of days of block method trials. The data were averaged for all animals for all days in a set. Only the seven most difficult comparison steps are included in the graph, because performance at the other steps was at, or close to, 100 per cent under both methods.

The performance curve under the block method shows a lower threshold than that under the staircase method. The differential brightness threshold was defined as the 75th percentile point. The two staircase method sets produced thresholds of 7.0 and 7.3 foot-lamberts; the block method produced a threshold of 7.8 foot-lamberts. As noted, thresholds were obtained in comparison with a standard brightness of 10.1 foot-lamberts. Thus, under the block method a difference of 3.3 foot-

lamberts was detected, as against 3.8 foot-lamberts for the best staircase data. The effect of an additional six weeks of practice is reflected in the slightly superior performance in the second staircase set. The block method curve also had a sharper slope, reflecting a greater change in performance with changes in stimulus magnitude than the staircase method.

Variability of performance at each comparison step was calculated using the standard error of the mean of the per cent correct as the statistical measure. This measure varied from 2 per cent to 8 per cent under both methods and no difference was found in variability of performance under the methods.

The influence of the sequence of steps under the block method was examined. Figure 3 shows the performance curves for ascending and descending sequences and indicates the superiority of the ascending sequence. Thus, there is a lower threshold when going from easier to more difficult comparisons than under the reverse sequence, as has been reported previously for humans.

The order in which the ascending and descending series were presented did not influence performance. That is, a sequence of steps 6 to 12, 12 to 6 will show the same results for each sub-sequence as a sequence of 12 to 6, 6 to 12. It does not matter whether the ascending or descending order is presented first.

Fig. 2. Performance curves for the eight rats under the three experimental procedures.

Fig. 3. Ascending and descending sequence performance curves during the block method.

Fig. 4. Performance curves for a typical subject, rat No. 9, under the three experimental procedures.

Figure 4 presents the averaged performance curves for a typical single animal under the three procedure sets.

Conclusions

The present data from animals parallel the literature on psychophysical measures for humans. As Blackwell reported for humans,

the block method produced the minimum threshold. However, the present animal data failed to find a decreased variability for the block method. Both block and staircase methods had comparable variability of performance for each step.

The block method exhibited a greater change in performance for a given change in stimulus magnitude. However, the threshold values produced by the staircase method were sufficiently close to those of the block method to suggest that little sensitivity would be lost if the staircase method were utilized, because of its unique ability to study changes in thresholds over short time intervals.

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