The Influence of Stimulus Presentation Number on Noxious Thermal Discrimination: A Methodological Study.

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Background

Indirect psychophysical methods utilising discrimination procedures (examples, confidence-rating and forced-choice) present stimuli repeatedly to determine the perceptual discrimination ability of subjects. In a laboratory setting, high stimulus presentation numbers are usually utilised. However, such an endeavour may not be practicable in non-laboratory settings.

Several factors may mitigate the use of high stimulus numbers in discrimination procedures using noxious stimuli. Firstly, hyperalgesia onset onset through repeated stimulation may distort the 'true' value of a measure representing the subject's noxious discrimination ability. Secondly, lower stimulus numbers may lower the statistical precision and accuracy of the result. Thirdly, when rating designs are used for the discrimination procedures, lower stimulus numbers increase the likelihood of yielding zero or perfect responses categories within the rating response set. In other words, the subject may either assign all or none of his/her responses to one category. However, there is little evidence regarding the possible biasing effect of low stimulus numbers on noxious discrimination ability measure. This study compared two stimulus numbers to determine the effect of presentation number on the discrimination ability measure. The relative efficiency, an index of statistical precision, of the procedures was computed to describe the statistical variability of the two stimulus numbers.

Methods

Ethical approval and choice of trial numbers

Queen Margaret University College Research Ethics Committee approved this study. Six healthy subjects (mean age = 25.5 years, sd = 7.9) were recruited from the students and staff of the university for this study. Informed consent was obtained from the subjects. Two Two stimulus presentation numbers were chosen based on a literature review of signal detection theory (SDT) studies (which used discrimination procedures) that investigated thermal pain perception. These numbers were the median stimulus numbers of studies that used parametric and non-parametric SDT measures. The stimulus numbers were 40 trials (range= 6-100) and 17 trials (range= 8-67) respectively. The assumption was studies that utilised parametric measures used relatively higher stimulus numbers in order to meet the statistical requirements for the use of parametric statistics. The stimulus numbers chosen were considered representative of the upper-bound and lower-bound median frequencies used for past studies.

Procedures

The study consisted of 2 sessions: one session presented the stimuli at 17 trials per stimulus stimulus intensity (N_{17}) and one session presented stimuli at 40 trials per stimulus intensity (N_{40}). Within each session, 3 noxious temperature-pairs (45°C & 46°C, 46°C & 47°C, 47°C 47°C & 48°C) were tested. Each temperature-pair was consigned to one block of testing. The 2 sessions, 3 blocks and trial sequences within the blocks were randomised. Within each block, the experimenter tested subjects' ability to discriminate between two thermal intensities. Contact thermal stimuli were administered via a Quantitative Sensory Testing machine (Somedic AG). The thermal stimuli were applied onto the subjects' dominant forearm using a Peltier contact thermode. Each trial lasted 3 seconds. After each trial, subjects rated their confidence of whether the higher or lower intensity of the temperature-pair was presented. The rating response set used by the subject is shown in figure 1. After each response, the subject was provided feedback on the actual temperature presented.

"1"	"2"	"3"	"4"	"5"	"6"
I'm absolutely confident that the weaker stimulus was presented	I'm fairly confident that the weaker stimulus was presented	I'm slightly confident that the weaker stimulus was presented	I'm slightly confident that the stronger stimulus was presented	I'm fair confident that the stronger stimulus was presented	I'm absolutely confident that the stronger stimulus was presented

Figure 1. Confidence-rating scale used by the subjects for discriminating noxious thermal stimuli

Results

Descriptive statistics

The signal detection theory index, d_a (unitless), was used to represent discrimination ability. Figure 2 shows the subjects' discrimination ability for the 3 temperature-pairs. The N_{40} d_a tended to decrease as the temperatures increased. However this trend was not evident for the N_{17} d_a. Post hoc trend analyses (linear trend) were performed for the within-subject effect of temperature-pairs and the interaction between stimulus numbers and temperature-pairs. No significant linear trends were found.

Relative efficiency

The statistical efficiency of a procedure is defined as the dispersion of the sampled values of the measure around the expected mean. A procedure is relatively more efficient than another procedure when it has a smaller dispersion of the sampled values around the expected mean. The d_a variances (a measure of dispersion) of the N_{17} and N_{40} were calculated, var(N_{17}) = 0.513 and var(N_{40}) = 0.295. The N_{40} procedure was relatively more efficient than the N_{17} procedure from the variance values.

Inferential statistics

A 2 x 3 (stimulus numbers x temperature-pairs) repeated measures ANOVA test was used to analyse the data. There were no significant main effects between conditions N_{40} and N_{17} ($F(1,5)=0.454$, $p=.531$). No significant interaction was found between the stimulus numbers and and temperature-pairs used ($F(2,10)=0.934$, $p=0.425$). Post-hoc pairwise comparisons between all the temperature-pairs' d_a for all conditions showed no significant comparisons.

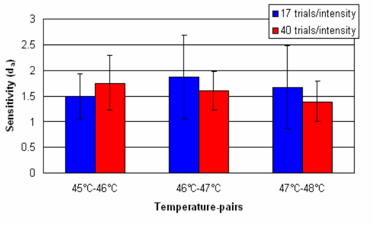

Figure 2. The discrimination ability (sensitivity) of subjects for the stimulus presentation number groups (17 trials vs. 40 trials) at different temperature pairs. The error bars show the standard deviation of the averaged discrimination ability.

Discussion

It was found that N_{40} procedure was relatively more efficient than N_{17} procedure. This finding was consistent with Hautus' (1997) and Miller's (1996) results. Their study found that when the stimulus number was decreased, the variability of the discriminative measure increased, hence relative efficiency decreased. The implication of this finding was that a trade-off should be found between the stimulus number and the variability of the procedure.

This study provided evidence that a lower stimulus number may provide an acceptable estimate of the discrimination measure. Since statistical non-significance may be influenced by statistical imprecision imprecision within the measure, checks of the averaged values and variances weres required. The measure variability of our study was considered adequate. Our study found no statistical differences between the discrimination measures of N_{17} and N_{40}.

The number of subjects employed in an experiment was a factor not considered in our study but examined in Hautus' (1997) and Millers' (1996) study. In the circumstance of unacceptable variability within the the discriminative measure due to low stimulus number, the use of higher number of subjects and data pooling may reduce the variability of the measure (Hautus, 1997).

Conclusion

No statistically significant difference was found for the discrimination measure between N_{17} and N_{40}. The use of a lower stimulus number, in our study, will not cause extreme deviation in the discrimination measure. However, the variability of the measure should be monitored and, if necessary, remedial measures (example, a larger sample size) built into the study design.

References

Hautus MJ (1997). Calculating estimates of sensitivity from group data: Pooled versus versus averaged estimators. *Behav Res Methods Instruments Computers, 29,* 556-562.

Miller J (1996). The sampling distribution of d'. *Percept & Psychophysics, 58,* 65-72

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