Advances in Pain Research and Therapy,
Vol. 3, edited by John J. Bonica et al.
Raven Press, New York © 1979.

Adaptation-Level Effects in the Rating of Acute Pain

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Signal detection theory (SDT) has provided important psychophysical advances, but its extension for the assessment of pain modulation techniques has been criticized (6–9) on both theoretical and methodological grounds. The present study undertook an examination of validity of the two fundamental assumptions made by most proponents of the SDT approach to pain. These are, first, that an analgesic which decreases the sensory component of pain will yield a reduction in the discrimination parameter, d′ (1,3,4), and, second, that changes in the criterion parameter arise from modifications of the subject's response bias or attitudinal predisposition (3,4). Rollman (8,9) has questioned these assumptions, emphasizing that an analgesic could modulate the sensory activity of the experimental stimuli, reducing both their neural impact and the pain they induce, while leaving intact the ability to discriminate between them and thus the d′.

A conceptual model of pain modulation was provided by the first experiment. Determinations of d′ were made before and after a reduction of sensory input achieved by attenuation of the noxious stimuli. Contrary to the general expectations of SDT investigators, d′ remained constant while the criterion showed a misleading shift toward a more conservative level. The pain ratings revealed a striking adaptation-level effect which was abolished by manipulation of the experimental design in a subsequent experiment.

METHODS

Three practiced university students received constant-current electrical trains (sixty 1-msec monophasic square wave pulses at 100 Hz). Two high-intensity (I_3 and I_4) current values were selected somewhat below the pain tolerance level. Observers received 63 presentations of I_3 and I_4 during half of each session and used an 8-point rating scale to report the resulting experience [nothing (1), tactile sensation (2), very faint pain (3), faint pain (4), mild pain (5), moderate pain (6), strong pain (7), and very strong pain (8)]. During the other half of

each session, subjects rated 63 presentations of I_1, and I_2, current values 8% lower than I_3 and I_4.

In a second experiment, four new observers participated in a replication of the first experiment (condition A) as well as a modification (condition B) in which I_1, I_2, I_3, and I_4 were presented randomly throughout each session of 252 trials. They were permitted to add plus and minus responses if the experienced pain seemed to fall between the suggested categories.

RESULTS

ROC curves were determined after cumulative treatment of the proportions of each of the pain ratings (4,9). As shown in Fig. 1, although the intensities of I_1 and I_2 *(triangles)* are considerably less than those of I_3 and I_4 *(circles),* the points for both sets of data fall along generally identical ROC curves. Therefore, the reduction in noxious input failed to affect the SDT parameter for the discrimination of adjacent pairs.

Differences exist, however, in the values of the criterion parameters. Points close to the lower left corner are described as reflecting an extremely conservative criterion (a bias to report an absence of pain), whereas those closer to the upper right corner are interpreted to represent more liberal criteria (a bias to

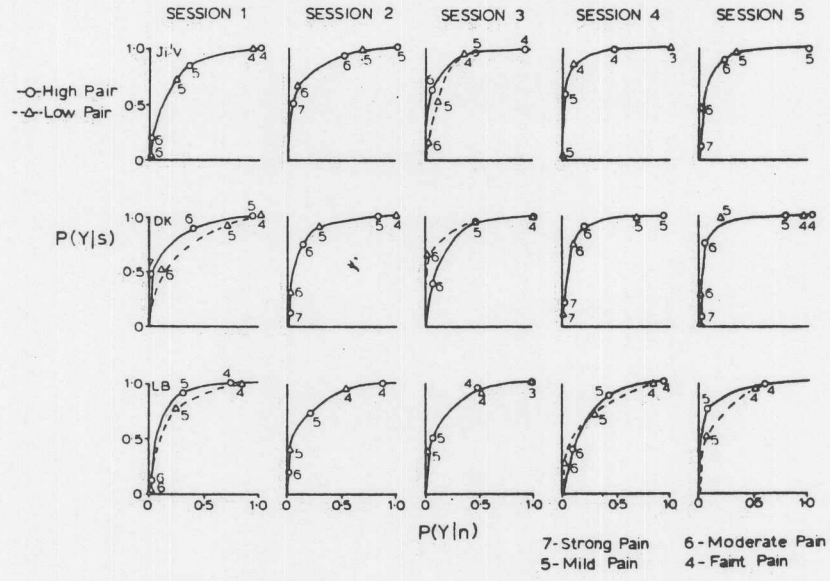

FIG. 1. ROC curves for each of 5 sessions for 3 subjects in the first experiment. Data points for the low- and high-intensity pairs fall along the same function, although the response criteria for the low pair appear almost consistently to the left of those for the stronger pair.

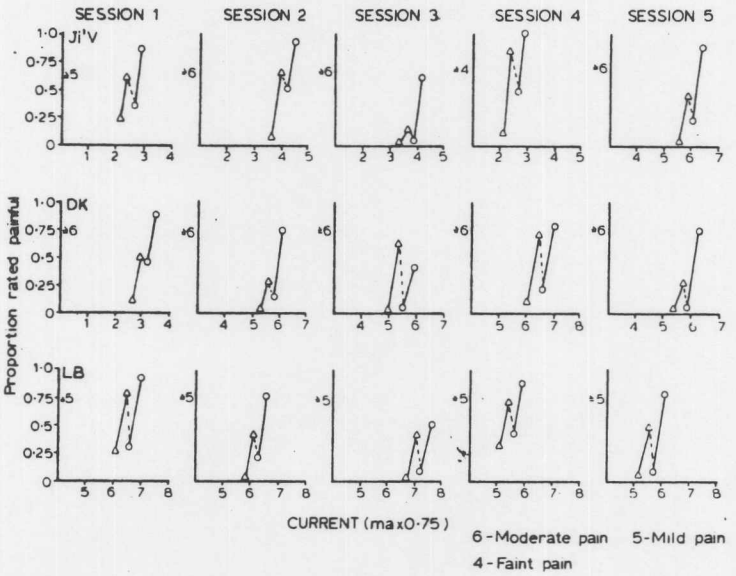

FIG. 2. The proportion of trials rated as painful for each of 4 stimulus levels. The lower pair *(triangles)* were presented during one-half of each session; the higher pair were presented during the other half.

report the presence of pain). In nearly all comparisons, the triangles (low pair) are closer to the lower left. By any of the methods used by pain investigators (e.g., 3, 4) to describe the criterion value (e.g., L_x, C_x, or percent bias), the criteria for reporting pain would have been said to change while the sensory component would have been judged to remain unaltered.

Figure 2 shows the proportion of trials at each intensity which the subject described as being fairly painful. Instead of the anticipated monotonically increasing relationship, the function shows a consistent "zigzag effect." Although I_3 was more intense than I_2, it was less often described as painful.

Since this effect seemed to arise from the matching conditions used in the first experiment (I_3 was always paired with the most intense stimulus; I_2 was paired with the weakest), the experiment was repeated with mixed presentations of the four current levels. As shown in Fig. 3, the zigzag effect was reliably present under the paired grouping (condition A) and absent under the mixed (condition B). In both instances, the d′ values for the low- and high-intensity pairs did not differ significantly. However, the mean d_e' in condition A (1.57) was significantly higher than d_e' in condition B (1.14) [$t(78) = 2.453$; $p < 0.01$]. This serves as a further caution in comparing published SDT parameters, since the experimental design influences the discrimination measures, violating the assumption of independent effects.

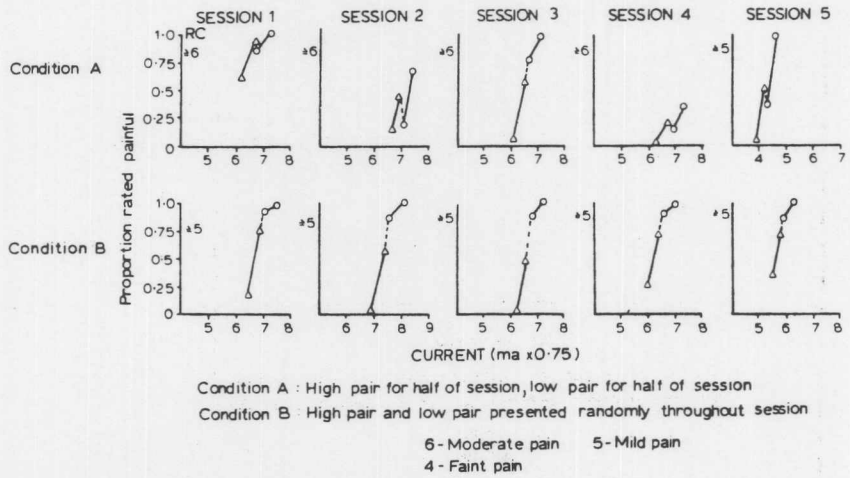

FIG. 3. The proportion of trials rated as painful for each of 4 stimulus levels in the second experiment. In condition A, each of the two pairs was repeated during half of the session. In condition B, the 4 intensities were mixed throughout.

DISCUSSION

The results of the first experiment failed to provide empirical support for the assumptions made by most SDT pain investigators. The discrimination measure remained constant when the sensory input was reduced, whereas the criterion measure mistakenly suggested that the response bias had shifted in a more conservative direction.

Detection, the special case of discrimination in which a weak signal is distinguished from a blank (internal noise), has been suggested (2) to provide a solution to this dilemma. However, numerous shortcomings of this approach have been reviewed (9). A demonstration of "additivity" (2) indicates that results within a particular experiment may be consistent, but it does not prove SDT validity. Moreover, the disruption of detection fails to provide any evidence for analgesic effects at painful levels.

The zigzag effects are reminiscent of the adaptation-level phenomenon described by Helson (5). His theory proposed that ratings are made with reference to a weighted average of the experimental stimuli. High or low intensities can change the frame of reference, altering the judgments because of contrast effects. The effect which was replicated in condition A of the second experiment, but eliminated in condition B, is in accord with the theory's predictions.

Ratings of I_2 may have been inflated because of contrast with I_1. Likewise, ratings of I_3 may have been underestimated. With pain patients, however, the outcome could be quite different. Under condition A, a strong internal comparison (the endogenous activity) could serve as the reference, eliminating the biases introduced by the weak or strong signals in nonsufferers. The absence of a

zigzag effect might reflect the pain experienced by the patient; its restoration might serve as a measure of a treatment's success.

ACKNOWLEDGMENTS

This research was supported by Grant AO-392 from the National Research Council of Canada. I am grateful to Marianne Sanders for her assistance.

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