MEDICAL PSYCHOPHYSICS

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Abstract

Psychophysical methods, data and theory have interesting clinical applications in the field of medicine. Physicians have special needs for new methods that reveal a patient's self-report of current health status. Subjects often are asked to express judgments about variables such as pain intensity, respiratory discomfort during exercise, and quality of life. Examples described in this paper are confined to pain assessment and its health implications. All assessment instruments discussed in this paper are computer administered and allow for expression of dynamic (continuous over time) judgments. Such assessment data can be evaluated by physicians in trying to understand the health status of their patients before, during, and after treatment.

Introduction

Traditional clinical research in health psychology asks patients to give judgments about health symptoms covering a wide range of issues, including pain, breathlessness, depression, appetite, and quality of life. The defining feature of all such assessments (regardless of mode of administration) is that they rely on questionnaires, interviews or *unidimensional* scaling methods.

This paper describes an approach that is not questionnaire based. Rather, it is a computer-administered, graphic procedure that allows the user to provide a quantitative evaluation of symptoms within a context of other items. The major features that differentiates these new techniques from earlier ones is that they are dynamic in nature over time, and encourage direct comparisons among different symptoms, rather than limiting the user to evaluations of individual components (one question at a time). A quantitative rating is accomplished by depressing and moving the mouse, by depressing the arrow keys on the keyboard, or via a touch screen. User initiation causes a bar to increase or decrease in length for an item, or causes the movement of a verbal descriptor along a scale. The bar length or location of the item on the scale indicates the rating (subjects are extremely accurate in judging the relative length of lines/bars as well as points along a line, Baird, 1970, Ch. 3). Using our techniques an individual can move back and forth among the items in order to create a rating for each. The simultaneous presentation of items in context encourages the user to make direct comparisons of the rating levels assigned to each of the variables, and we have shown that such comparison leads to more discrimination among different facets of an issue (Baird & Chawarski, 2001). In addition, the use of an adjustable bar or item location, instead of a single mark along the scale, allows the user to "fine-tune" ratings before deciding on a final setting.

So far in the research program we have conducted studies in a Pulmonary Exercise Laboratory (Mahler et al., 2001; Mahler, Fierro-Carrion, & Baird, 2001), an Audiology Clinic, a Pain Management Center (Fancuillo et al, 2001), and in a drug-abuse treatment program (Chawarski et al., 2001). Because the psychophysical methods are very similar or identical in all these applications, the work on pain assessment can serve as a means to convey the flavor of what we refer to as Medical Psychophysics.

Overview of Pain Studies

A series of studies (approved by the Dartmouth Committee for the Protection of Human Subjects) was conducted to evaluate several pain assessment methods and to collect data from patients being treated at the Pain Clinic at Dartmouth-Hitchcock Medical Center. Tests were also conducted with a smaller group of controls recruited from a local health club and senior center. Potential participants were asked to volunteer "for a study regarding ratings of pain (or quality of life), taking about 10 minutes." The studies with patients took place in a treatment room in the Clinic, and so far have involved 338 patients. A total of 218 control subjects also have completed some of the procedures in a local health club and senior center.

Computer Platform

The pain assessment methods were implemented using proprietary software developed by the author and Marek Chawarski of Psychological Applications (Provisional Patents #60/270,854 and #60/292,115) and were run on an iBook Macintosh G3 computer. The software is written in the True Basic language and is compatible with both Macintosh and PC platforms.

The software stores subject ratings in a separate file for later statistical analysis. A patient's data are arranged in a manner that allows a physician to access a single individual's record and automatically compare these data (in graphic form) with that of all other patients who have completed the same task. In addition, each computer keystroke is tagged for later analysis, allowing for a complete animated reconstruction of the entire judgment process (e.g., order of moves, number of moves, time of moves). These results will not be presented here. Each study began with a practice trial to familiarize the individual with the computer methods subsequently employed for rating pain intensity, location, emotional impact, and quality of life.

Scaling Pain Intensity and Its Emotional Impact

A horizontal linear scale (14 cm long) was presented on the screen with major tick marks (vertical orientation) at equal intervals stretching from zero (left most point) to 10 (right most point). Minor tick marks appeared between the major marks. The successive integers 0 to 10 were situated above the major marks. The label "NONE" anchored the low end of the scale and the label "MAXIMUM" anchored the high end. The words "PAIN INTENSITY ON A TYPICAL DAY" appeared immediately above the scale for ratings of intensity and the words "EMOTIONAL IMPACT ON A TYPICAL DAY" appeared for the emotion ratings. At the top of the screen for the pain rating the patient was instructed to "Indicate the absolute degree of your pain," and for the emotion rating the patient was instructed to "Indicate the absolute degree of your pain's emotional impact." Beneath this sentence patients received instructions to "use the left and right arrows on the keyboard to adjust the bar to the desired length." Patients ($N = 115$) made ratings by adjusting the length of a green bar (1 cm in width) that changed in direct proportion to the depression of the 'left' or 'right' arrow keys. The adjustment process continued until the subject was satisfied with the rating.

The histogram in Fig. 1 (left panel) shows the mean (SD) pain intensity and emotional impact, where it can be seen that pain intensity is rated somewhat higher than emotional impact. The relation between individual ratings of pain intensity and emotional impact is shown in Fig. 1 (right panel), where the correlation between a patient's two ratings is $r = 0.34$ ($df = 113$, $p < 0.05$, two-tailed test).

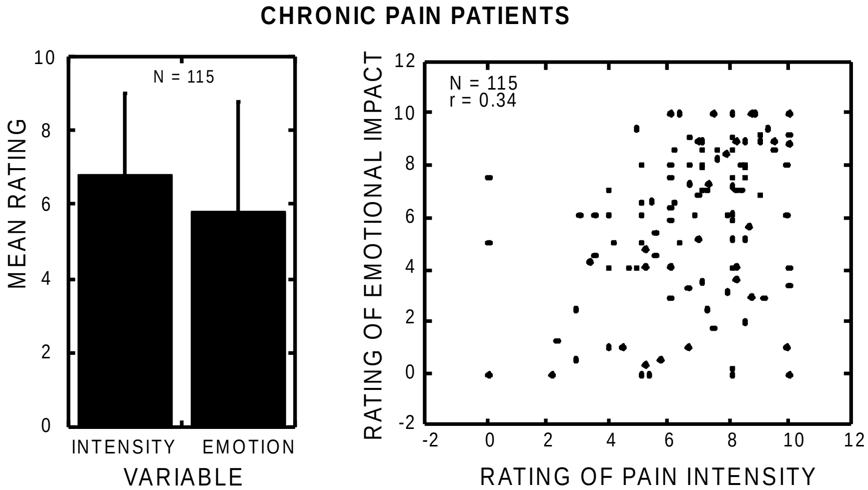

Figure 1. (left) Mean and standard deviation of pain intensity and emotional impact. (right) Rating of emotional impact as a function of rating of pain intensity (N = 115 chronic pain patients).

S*caling Word Descriptors of Pain and Emotion*

The patient was asked to rate each of a set of descriptors as to how well it described their pain. The patient was allowed to change the configuration of descriptors along the scale until the most accurate representation of his/her pain characteristics was achieved. The method was tested with 115 chronic pain patients who rated the appropriateness of adjectives describing the nature of their pain, and on a separate display, the appropriateness of emotional terms describing the emotional impact of their pain. An age and gender matched control group (N = 115) rated their "perception" of what they would expect a person in chronic pain to give as a rating. Words initially appeared in a vertical list on the screen and a single linear scale appeared bottom-right with numerical values (integers 1 to 10), tick marks and verbal anchors. The user dynamically moved the words (descriptors) to positions along the scale to indicate the degree to which the descriptor was appropriate for their pain (actual or perceived) or for the emotional impact (actual or perceived) of their pain. Item movement was accomplished by using the arrow keys on the keyboard. The 'up' and 'down' arrows highlighted the word to be moved (color coded in "blue"). Depression of the 'left' and 'right' arrows moved the word along the horizontal scale. The system automatically erased the old representation of the word and drew it in the new location. This occurred continuously as the arrow key was being depressed.

The horizontal movement of a single word along the scale led to a corresponding change in the position of a red arrowhead that slid along the scale and pointed to the rating at that moment in time. The words were located in separate rows above the horizontal scale, so that more than one descriptor could receive the same rating without the words overlapping.

As words were moved along the scale, the user rated the new words with respect to the scale and relative to the other words already placed along the scale. The method allowed the user to continue manipulating the positions of the words until satisfied with all the ratings.

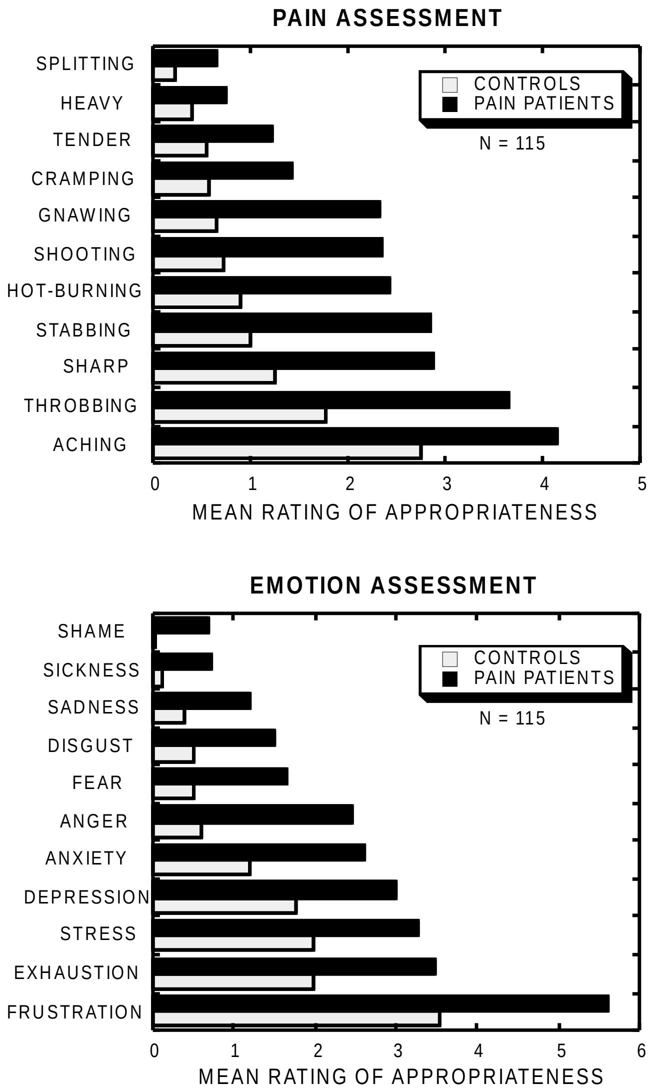

Figure 2. (above) Histogram of mean ratings of 115 patients (in pain) and control subjects (not in pain) for 11 pain descriptors. (below) Histogram of mean ratings by the same individuals of 11 descriptors of the emotional impact of pain.

The data being recorded included which word was moved, the order for each move, and the time required for each move. Figure 2 (left panel) is a histogram showing data for 11 pain descriptors indicating their relative appropriateness (Least to Best) for describing the character of the pain as rated by both the pain patients and the controls. Pain descriptors were taken (by permission of the author) from the McGill Pain Questionnaire (Melzack, 1983).

The symptom “aching” was rated as the most appropriate and the symptom “splitting” was rated as the least appropriate. Figure 2(right panel) shows comparable data for the appropriateness of words for describing the emotional impact of pain. Five of the 11 emotional descriptors were taken from Wade et al. (1990), three from the McGill Pain questionnaire, and the we added three more to extend the range of emotional terms. Control subjects maintain essentially the same rank order among the pain descriptors and among the emotional descriptors as do pain patients. Most importantly, all ratings rendered by pain patients are visibly higher than those rendered by control subjects not in pain. This should be taken as a preliminary indication that the method is a valid pain assessment instrument.

One advantage of this method over traditional means of obtaining ratings for each symptom in isolation is that judgments are made within a “context” of other symptoms, thus encouraging the user to make finer distinctions among the symptoms as reflected in their ratings. We have found that when pain symptoms are rated one by one, patients tend to choose high ratings of appropriateness for all the descriptors (both emotional and pain). A second advantage is that subjects are allowed to continuously change their ratings over time, thus allowing them to dynamically fine-tune individual judgments within the context of other judgments. The data collected to date indicate that such a rating method leads to a more accurate representation of a patient’s pain characteristics.

The correlation between the mean ratings of the two groups for the pain descriptors is 0.90 and for the emotion descriptors, 0.98. However, the data also indicate that the controls markedly underestimate the degree of appropriateness of both types of descriptors for characterizing pain. Although people not in pain have an accurate representation of the relative appropriateness of pain and emotion descriptors, they underestimate the quantitative amounts assigned by patients. This may be taken as evidence that the absolute value of a patient’s rating of pain is not simply a matter of individual choice, but rather, does indeed reflect the real symptom of pain. Otherwise, one would expect the controls (on average) to have given the same absolute ratings as the patients.

Maps of Pain Locations on the Body

We also have used a computer version of the McGill Pain Questionnaire (Fig. 3) to have 120 chronic pain patients map the locations of their pain on the outline figures of the human body. This mapping was accomplished by having the user move the cursor (by manipulating the mouse) and depressing the mouse. Either single locations (pointing and clicking) or entire regions of the body could be marked in this manner (by holding the mouse button down while moving it). Marked locations were designated by the appearance of small red squares. The program permitted the user only to mark locations within the outline of the human figures. Subjects were allowed to mark up to three different locations as either single spots or larger regions.

For the purpose of the data analysis the human body outline was digitized into larger squares (extended locations). The raw data were then analyzed by computing the total number of times each extended location was marked. We then computed the 25^{th}, 50^{th}, and 75^{th} percentiles of marking frequencies and color-coded the pain figures accordingly. Data have been recoded as a gray scale; the results of this analysis are shown in Fig. 3. The darker the shading of a location, the greater the number of times it was selected as a pain location. The results indicate that the most frequently marked locations (75 to 100^{th} percentile) are at the base of the neck and in the small of the back, with secondary (50th to 75th percentile) peaks in adjacent back areas, on both knee caps, and in the region of the right wrist.

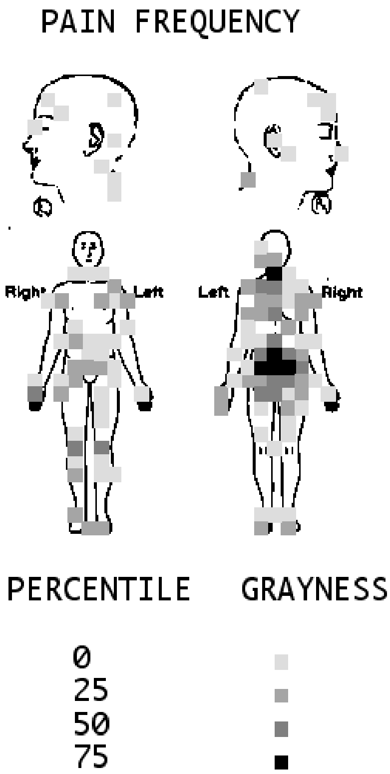

Figure 3. Locations marked by chronic pain patients to indicate painful spots or regions of the body. The darker the square the greater the number of "hits" obtained from a group of 120 chronic pain patients

Perceived Quality of Life

The final study in this series was designed to test a new rating method of quality of life that assesses the multidimensional impact of chronic pain. A software program assessing 20 categories of quality of life was created and administered to 103 chronic pain patients. Comparison data were obtained from 103 matched healthy controls. Bi-polar, visual analogue scales for each of four superordinate categories (Day-to-Day Functioning, Health Status, Self Esteem & Energy Level) and 16 subordinate variables were presented on the computer screen and subjects adjusted the length of a bar to indicate level of positive or negative feelings (degree of satisfaction or dissatisfaction) for each. Individual scales ranged from plus 10 (extremely positive) to minus 10 (extremely negative), and items were displayed on the computer screen in clustered groups of four.

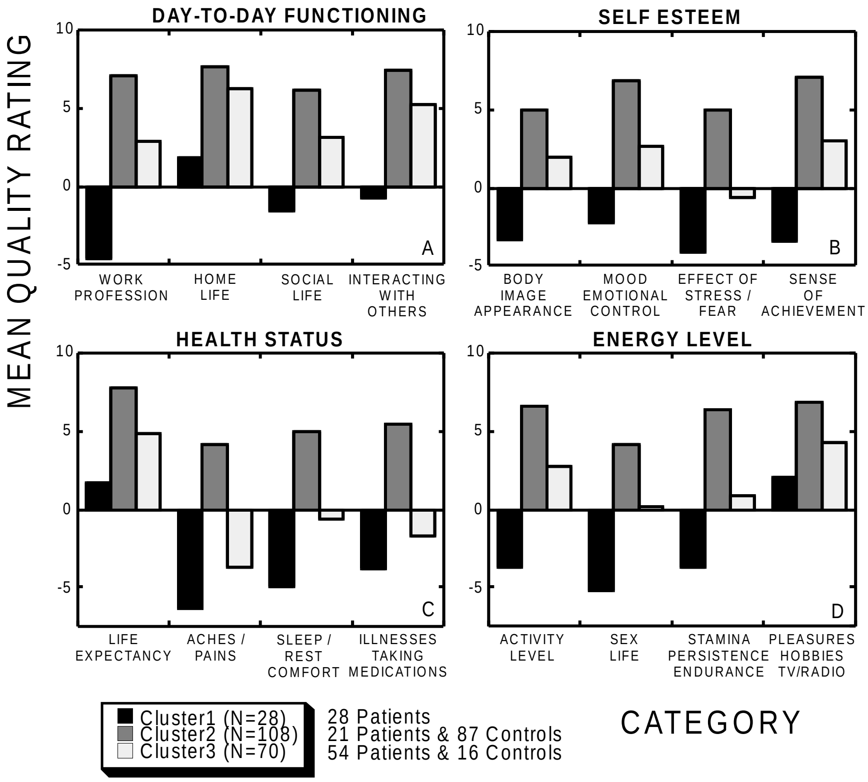

Figure 4. Mean ratings for patient and control groups (combined) for the subordinate categories under each of four superordinate quality of life variables. Each panel (A, B, C. D) shows data for four categories that were presented and rated together on the computer screen. Separate histograms shown for each of three groups of subjects identified by k-means cluster analysis.

Large variability was found among pain patients in their ratings of quality of life, and they rated all categories lower than controls. However, three subject groups emerged from a cluster analysis of the combined data reflecting high, mixed, and low ratings of satisfaction with quality of life. Results for the three groups on the subordinate quality of life variables are shown in Fig. 4. Further investigation of the validity and reliability of this software is currently underway.

Clinical Implications

Paper-and-pencil methods for assessing medical symptoms are commonplace, expensive, and time consuming. One of their major drawbacks is that raw data first must be manually entered into a computer before a researcher or clinician can search for possible patterns among multiple aspects of the rating of symptoms. For this reason, very few attempts have been made to seek such patterns. With the on-line collection of large amounts of self-report data it is now possible to begin to identify patterns among measures that might help the physician distinguish among viable diagnoses and the effectiveness of alternative treatment programs. In addition, the existence of a large pool of assessment data will allow physicians to examine aspects of the judgment process itself that might be linked to specific illnesses. Such an undertaking would be impractical with current paper-and-pencil instruments. One can envision a day when a physician will have instant access to a patient's history of self-reported medical symptoms, including their intensity, character, location, and emotional impact. In addition, the clinician will have the ability, by accessing a Web site, to select among alternative comparisons between a single patient's ratings of health symptoms and those of other individuals of known medical diagnosis, treatment history, and demographics.

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