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Measurement of Experimental Pain in Chronic Pain Patients: Methodological and Individual Factors

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A recent issue of the journal *Pain* includes five papers with the word "pain" in their titles. One (34) superbly reviews the literature on cognitive methods for pain control in humans and provides an overview of studies in which the discomfort arose due to muscle ischemia, ice water, electrical shock, heat, pressure, endoscopic examination, knee arthrogram, cast removal, cardiac catheterization, surgery, dental procedures, muscle contraction headache, childbirth, and duodenal ulcer, among others. The remaining four examine the pain due to electrical shock, chronic low back pain, diverse pain syndromes, and phantom limb pain.

Those interested in the measurement or treatment of pain wish to generalize across studies—to read reports emerging from one laboratory or clinic and apply the findings to their own specific needs. However, even a casual review of the pain literature reveals repeated instances of inconclusive outcomes and failures to replicate effects reported elsewhere. Given the enormous range of pain-inducing stimuli and syndromes described above, such discrepancies are not surprising.

An understanding of the sources of these differences, however, is crucial for an adequate theory of pain. In recent years, scientists have made considerable progress in isolating specific neural, biochemical, psychological, and social factors that influence the response to noxious stimulation. This chapter presents a selective examination of some of those elements that appear to be important in comprehending the existing literature and in planning future studies.

THE VARIETIES OF PAIN

Laboratory-produced pain and acute and chronic clinical pain differ in both the source of the discomfort and the motivational and cognitive reactions of the individual. Other chapters in this volume emphasize some of the dominant issues concerning the validity of generalizing from the laboratory to the clinic. A declared feature of experimental pain is the capacity to control precisely the spatiotemporal characteristics of the stimulus. This, however, is hardly advantageous if the results obtained in the laboratory are irrelevant to the demands of the clinic. Such a pessimistic stance is unwarranted; nonetheless it is imperative that laboratory procedures and measures be verified in a wide variety of clinical studies.

Pain Induction Methods

Stimuli that can be readily controlled, precisely calibrated, and easily applied, and that are nonhazardous are widely available (26). They fall into a number of broad physical categories, containing considerable choice within each: mechanical (pressure on skin, tourniquet), thermal (heat, cold), electrical (cutaneous or tooth pulp stimulation), and, less satisfactory, chemical (cutaneous, subcutaneous, intramuscular).

Are these interchangeable in pain investigations? Discrepancies in the literature may relate to either the source of the pain or the responses signalling its presence. In humans, these components can be isolated. If indices of responsiveness are obtained for several different stressors, will individuals show similar patterns of sensitivity to all?

Past results (5,9,10,36) have been equivocal, so Georgina Harris and I tested the convergent and discriminant validity (6) of three different pain induction procedures in a group of 40 subjects. Pain thresholds and tolerances were obtained, along with subjective ratings, for (a) a train of electrical impulses delivered to the forearm, (b) a cold pressor test, in which the forearm was immersed in a tank of circulating ice water, and (c) pressure applied through a plastic wedge against the first phalanx of the subject's forefinger (12).

The stimuli varied in locus, energy, and method for determining thresholds. For electrical shock, the stimuli were presented intermittently in ascending intensity, whereas for cold and pressure the physical intensity was constant, and the duration of the stressors was extended. Nonetheless, observers were relatively consistent in their behaviors. Correlations tended to be significant both within a given pain source and across stressors.

Despite the evidence for validity (6) of both traits (pain measures) and methods (stressors), there are a number of reasons for caution in concluding that these electrical, thermal, and mechanical stimuli are equally satisfactory in testing pain attenuation. First, the correlations, although statistically significant, were generally between 0.3 and 0.5. Second, some serious differences among stressors were revealed by the concurrent rating data. Subjects received instructions to report when the stimulus became painful and to tolerate the discomfort as long as possible. At both decision points, they also described their pain experience by marking a scale that included both words and numbers: slight pain (1 to 4), moderate pain (4 to 7), severe pain (7 to 10), and very severe pain (10).

For the three stressors, the following are the average ratings provided at pain threshold and tolerance points:

	Shock	*Cold*	*Pressure*
Threshold	1.77	3.80	3.72
Tolerance	5.92	7.92	7.12

It appears that for shock, subjects withdrew from the experiment while their pain was still fairly moderate; for cold and pressure it was described as somewhat severe. Clearly, threshold and tolerance do not mean the same thing for different stressors.

Which, then, is the preferred induction method? Shock was the only one of the three stressors that showed significant correlations with personality measures (17). Is shock unacceptable because it is subjectively the one that is most unlike clinical pain and the one for which the tolerance criterion may be the lowest, or is it desirable precisely because factors such as anxiety, which are responsible for this cautious behavior, are also the ones that provide the closest parallel to the affective and evaluative components prominent in the clinic?

The method of pain induction is not an issue that can be examined in isolation. Interactions between pain source and pain attenuation may occur, leading one laboratory to conclude that a putative analgesic is without effect while another laboratory, using a different source of pain, proclaims its striking antinociceptive properties. Often, the pain source is chosen on the basis of what apparatus is readily available rather than by an informed judgment regarding its capacity to mimic the sensory, affective, or evaluative properties of particular clinical disorders. Even a single form of energy, such as electrical shock, can produce vastly different effects as a function of both its pulse properties and experimental locus (27). Pain researchers should expand their arsenal and replicate their results with a variety of stressors, thereby establishing a meaningful comparative perspective on the interaction of different treatment modalities and different forms of pain.

Pain Measures

Just as there are a wide variety of pain induction methods, there is now a plethora of direct and derived pain measures: thresholds, tolerances, categorical judgments, magnitude estimations, signal detection theory (SDT) indices, visual analogue scales, multidimensional scaling, cross-modality matches, scaled verbal descriptors, functional measurement, the McGill Pain Questionnaire (MPQ) and other checklists, nonverbal pain expressions, cortical evoked potentials, autonomic indices, withdrawal reflexes, and, in the case of clinical pain, behavioral correlates such as activity levels or drug intakes.

It would be folly to assume that each of these reflects the same attribute, yet relatively few investigators (e.g., 1,2,4,13) utilize more than one nociceptive measure. As was the case with pain induction, a comparative perspective is required here, so that the full complexity of the human pain experience can be adequately expressed.

The emphasis of the gate control theory (23) on the sensory–discriminative, motivational–affective, and cognitive–evaluative components of pain has fostered attempts to develop scales which assess each of these dimensions. The MPQ (22) and the verbal descriptors and cross-modal matches utilized by Gracely and his colleagues (e.g., 14) represent important steps in quantifying the multidimensional nature of nociception.

However, since pain is a complex integration of these elements, it remains to be seen whether they can be measured independently. Melzack (22), for example, determined correlations between the rank values of each MPQ subscale: sensory, affective, evaluative, miscellaneous, as well as total. All correlations were significant at the 0.01 level.

Although Gracely has presented data that indicate that sensory and affective components can be dissociated (e.g., 14), both judgments were generally not obtained at the same time. More recent results (37) demonstrate that not all psychophysical attempts to assess these two components are equivalent; in a group of chronic low-back-pain patients, verbal scales of both sensory intensity and unpleasantness of noxious thermal stimuli were significantly reduced when compared with a placebo by administration of morphine, whereas handgrip measures of each were not reduced by the drug.

Pain measures utilizing verbal responses may include items not understood by sizeable numbers of patients or subject to multiple interpretations. Even simple words create difficulties: "Intense" and "miserable" are both included on the evaluative subclass of the MPQ; others (15) used the former as a sensory descriptor and the latter as an affective one.

In my own laboratory, SDT measures of discrimination of electrical shocks presented to the forearm were not reliably affected by instructions to rate the intensity, unpleasantness, or painfulness of the stimuli, although discriminability was improved when observers concentrated on distinguishing the stronger signal from the weaker (30). More recently, Elizabeth Nowicki and I compared the MPQ with concurrent visual analogue scales and direct magnitude estimations of the sensory intensity and unpleasantness experienced by a group of patients receiving spinal blocks. The correlations of the MPQ subscales were similar to those reported by Melzack (22). As well, for both visual analogue scales and ratio judgments, intensity and unpleasantness showed highly significant correlations with each other. The changes in pain, both within and across sessions, were not reflected equally by these measures (see also 19). Further attempts to refine multidimensional techniques and identify the limiting characteristics of verbal and performance scales (e.g., 14) are clearly in order.

Subject Characteristics

Research on pain generally involves either the endogenous discomfort of patients or induced stress in pain-free volunteers. Rarely do investigators study experimental pain with clinical subjects. Several years ago (29), I presented data that suggest that judgments of pain are based on comparisons with other pain levels and proposed an adaptation level model for such decisions. I suggested, as well, that whereas pain-free individuals refer to other stimuli in the pain-inducing set, chronic pain patients may utilize their internal discomfort as an anchor in describing an external signal's intensity or unpleasantness. Anecdotal reports reinforce this view. A newspaper columnist (32) related the story of an arthritic woman who failed to recognize an attack of acute appendicitis, adding "you must be in considerable pain when you can't recognize the addition of a new pain of that magnitude."

Recently, Naliboff et al. (24) tested the adaptation level concept, contrasting it with a hypervigilance model (see 8). The adaptation level model predicts that pain patients should have higher pain thresholds than controls—that is, the externally produced pain should not seem very severe when compared with the internal distress. The hypervigilance model assumes an exaggerated focus on painful sensations and predicts that pain patients will have lower pain thresholds than controls. In their study, Naliboff et al. compared radiant heat thresholds and ratings provided by low-back-pain patients, chronic respiratory patients, and nonpatient controls. The pain patients (as well as the respiratory disease ones, perhaps as a result of a history of painful diagnostic tests) had substantially higher pain thresholds than controls and showed poorer discrimination at lower intensity levels, thus supporting the adaptation level model. Related demonstrations that experimental pain thresholds or tolerance levels are reduced by successful treatment of painful conditions are available from the research of Nyquist and Eriksson (25) and Greenhoot and Sternbach (16).

Interestingly, in a study of patients with myofascial pain dysfunction (MPD) syndrome, a disorder attributed to muscle tension arising from emotional stress and anxiety, Malow et al. (20) found that they reported lower thresholds than nonpatients with the Forgione and Barber (12) pressure algometer and significantly lower discriminability in a signal detection task. A subsequent experiment by Malow and Olsen (21) found similar distinctions between unimproved and improved MPD patients. The threshold data suggest possibly important differences in the judgmental behavior of individuals suffering from psychogenic versus organic disorders; the signal detection results provide a challenge to those advocates of SDT (28) who argue that reductions in discriminability are the expected consequences of analgesic procedures, since the pain-free individuals exhibited increased discriminability indices.

These findings indicate that a synergistic relationship may be obtained from a convergence of traditional approaches. Experimental pain can be adjusted and quantified; clinical pain involves special affective and evaluative components. Testing chronic pain patients under laboratory conditions captures the benefits of both conceptual models.

Subject characteristics are not defined only by pain patient versus nonpatient distinctions. A massive body of literature has developed demonstrating the influence of other factors on the pain experience, and further research is needed to uncover their interactions with pain production, pain measurement, and pain state. Among these factors are age, sex, cultural and racial group, prior social experiences, psychiatric status, intelligence, expectation for pain relief, laterality, endorphin levels in cerebrospinal fluid, menstrual cycle, diurnal cycle, circannual cycle, and a host of personality variables including anxiety and coping style. As well, pain responses are affected by interactions between the subject's characteristics and those of the experimenter.

Cognitive strategies appear to be particularly promising in assessing the response to pain (17,33,35) and in planning appropriate treatments (34). Harris (17), for example, has shown that self-generated strategies (emphasizing "coping" rather than "catastrophizing") influence base-line responses to painful stimuli and interact with subsequent instructions in determining the success of brief cognitive therapies.

DOLORMETRICS

This chapter has emphasized the importance of methodological and individual factors in understanding pain experience. Pain cannot be studied in isolation. Judicious selection of induction techniques, response scales, and subject characteristics constitutes a critical part of the measurement process.

The problems identified here are not unique to the study of pain. Questions relating to individual differences and the relation between affect, evaluation, and behavior in both laboratory and natural situations have arisen in areas as diverse as social cognition (18), sexual behavior (11), aggression (3), intelligence testing (7), and the psychological factors underlying placebo effects (31). Psychometrics is a vibrant discipline that concerns itself with the measurement of mental traits and processes. Given the theoretical and empirical advances in pain research that have taken place in the recent past, dolormetrics, a science devoted to the measurement of pain, appears similarly promising. The task will not be easy. Pain source, measure, and subject characteristics each includes a multitude of categories, leading one to imagine a rather unwieldy Rubik's cube to describe the conceptual trinity presented here. Since even the conventional cube has the potential for 43 quadrillion configurations, considerable challenge and excitement lie ahead.

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