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INDIVIDUAL DIFFERENCES IN COLD PRESSOR PAIN TOLERANCE

by

JOHN P. KUHL

A dissertation submitted to the
Graduate Faculty in Psychology
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy,
The City University of New York

2001

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Supervisory Committee

THE CITY UNIVERSITY OF NEW YORK

ABSTRACT

INDIVIDUAL DIFFERENCES IN COLD PRESSOR PAIN TOLERANCE

by

JOHN P. KUHL

Advisor: W. Crawford Clark, Ph.D.

Verbal ratings during cold pressor stimulation were made by 31 pain-tolerant (PT) and 73 pain-intolerant (PI) normal healthy men and women of African-American, Euro-American, and Puerto Rican descent. PTs all endured 180 seconds of ice-water immersion; PIs endured 53 [SD 36] seconds. The latency to report SEVERE PAIN was significantly longer for PTs than PIs, but latencies to reports of COLD, VERY COLD, FAINT PAIN, and MODERATE PAIN did not differ between groups. PTs reported significantly more pain and more severe pain than did PIs. In response to the Multidimensional Affect and Pain Survey (MAPS) immediately following immersion, PTs reported higher mean ratings for significantly greater numbers of both SOMATOSENSORY and EMOTIONAL word clusters and individual words, but there were no differences in WELL-BEING ratings. PTs and PIs did not differ in State or Trait Anxiety, on any subscales of the

Brief Symptom Inventory, or on any hardiness scales of the Personal Views Survey. Results indicate that 1) PTs do not demonstrate lesser pain sensitivity or general willingness to report pain than PIs, but do endure more stimulation before calling pain "severe," and 2) PTs and PIs do not significantly differ in a range of personality measures including anxiety. Future studies are suggested to further explore what accounts for greater pain tolerance by some individuals.

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Still others were not involved in this dissertation project but certainly had impacts on my graduate training. Sol Steiner invited me to apply to the Experimental Cognition program. Lisa Bell introduced me to the New York State Psychiatric Institute. Murray Glusman hired me in my first position at the Research Foundation for Mental Hygiene. Larry Welkowitz provided my clinical supervision in the Behavioral Medicine program at Columbia Presbyterian Medical Center.

There are fellow students who I regret are now separated from me by time and or distance, including Ken Podell, Donna Hitchcock, Irit Aghion-Sa'ar, Maia Nadler, and Marla Hamberger, but I am fortunate that there are those who will always be with me: Sandra Brown (now Kuhl), Paula McKinley, Chris Christodoulou, and Hilary Gomes.

DEDICATION

This thesis is dedicated to the memories of

Donald P. Heller, Ph.D.

and

Louis J. Gerstman, Ph.D.

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INTRODUCTION

I. Specific Aims

Why do some individuals tolerate more pain than others? That some individuals stoically bear what is assumed to be excruciating pain while others complain dramatically about conditions of frankly questionable painfulness is a classic paradox (Beecher, 1959; Turk & Flor, 1999; Boothby et al., 1999).

Leaving aside unconscious motivations of secondary gain or even conscious ones of deliberate dissimulation, what accounts for variability in pain tolerance? The issue of individual differences in pain tolerance is addressed in the current study by reducing it to a series of simpler empirically testable questions.

The first question is whether pain tolerance is attributable to a difference in the perception of pain sensation. Do pain-tolerant individuals report less pain in response to a calibrated noxious laboratory stimulus? If there is a difference in perception, is it restricted to noxious intensities or is it more general, extending to non-painful sensation as well? Psychophysical scaling provides a method of answering this question, by allowing the comparison of stimulus-response functions, that is, plots of response magnitude as a function of stimulus intensity, of pain-tolerant and pain-intolerant individuals.

The second question is whether pain-tolerant individuals are more stoical, experiencing the same amount of sensory pain but finding it less emotionally distressing. Do they report the same magnitude of painful sensory stimulation, but with fewer negative cognitive and affective consequences in response to the pain? Additionally, is pain tolerance in part attributable to a difference in "positive" emotional responses to pain? This refers to a euthymic dimension that is infrequently investigated, the typical exception being the role of coping as it affects clinical pain (Keefe & Gil, 1986; Boothby et al., 1999). Verbal scaling techniques are useful for measuring these semantic variables, as long as there are enough sensory, affective, and cognitive qualities being measured. As Clark et al. (1989) have written, "multidimensional pain requires multidimensional scaling."

The third question derives from a complementary line of inquiry regarding the influence of personality traits which may predispose pain-tolerant individuals to respond in a relatively attenuated way to painful stimulation. In particular, 1) How stable are pain response styles? Do pain-tolerant individuals generally regard all painful events as being less painful? And, 2) what are the roles of negative and positive emotional *predispositional* factors? In particular, are pain-tolerant individuals characterized by less anxiety (and if so, what kind)? Additionally, are pain-tolerant individuals characterized by greater psychological hardiness (Kobasa et al., 1982).

II. Significance

A. Pain Tolerance

The capacity to endure pain is biologically adaptive. Fight, flight, or the hunt must go on despite pain in order to survive. The inevitable minor discomforts of daily life would exact a serious toll on productivity if they were not tolerated and disregarded with relative ease. More than minor discomforts also need to be tolerated if races are to be won, children are to be born, or tattoos are to be worn.

Pain endurance can be heroic, transformative, a portal to higher states of consciousness. Self-mortification in many cultures has served as a path to grace, transcendence, or enlightenment. Enduring pain for its own sake, however, can be regarded as pathological behavior. Borderline personality patients self-inflict pain to feel alive (Russ et al., 1996) and the desire for pain by masochists can strain public understanding (Brame et al., 1995).

Variability in human pain tolerance is commonly observed, but the nature of that variability is not particularly well understood. Although the athlete and the coach, the drill instructor and the new recruit, the torturer and the victim know that pain tolerance can be learned, there are nevertheless those who from the outset are recognized to be able to or choose to tolerate more, sometimes much more, pain than others. Navy seals, Olympic athletes (who participated in contests called "agons"), and certain performance artists are selected, often self-selected, for among other talents an extraordinary capacity to tolerate pain and discomfort.

Health care providers have at least a practical interest in pain tolerance. Being part of the culture in which they work, their beliefs about how much pain is appropriate, tolerable, or desirable are based on learned norms. In the United States, these evolved from the principles of the Puritans who brought with them a Calvinist doctrine sanctifying hard work and austerity, cherishing diligence and perseverance and eschewing pleasures and leisure. To seek comfort and, even worse, idleness, was not consistent with the work ethic which defined American culture for the succeeding centuries. Moreover, by virtue of the westward expansion, from the earliest colonial times through the 19th century, life for many was characterized by the harshness of wilderness environments.

B. The Current Status of Pain Treatment

In a social context evolved from such a heritage, and without an in-depth understanding of pain tolerance, both health care providers and patients (American Pain Society Quality of Care Committee, 1995) have behaved at the mercy of assumptions. Such assumptions can insidiously lead to the conclusions that analgesia is not necessary for a quiet patient, because one is not complaining; for post-operative or cancer patients, because pain is inevitable; for circumcised infant boys, because they will forget; for screaming patients from another culture, because it is just their way to scream.

Inconsistencies between pain and pain behavior or pain report are not disputed when they can be explained by neurophysiology. No one insists to a patient with allodynia that a breeze is not painful, or to a child with congenital pain insensitivity that he should feel pain when he cannot. Without a known physiological mechanism, however, variations in pain report and pain tolerance can be accorded the status of quaint medical anecdotes.

For example, Zborowski (1969), the medical anthropologist, conducted an extensive study of ethnocultural differences in response to low back pain among four groups of hospital inpatients: Jews, Italians, Irish, and "old Americans." Simply stated, Old Americans and Irish patients were relatively stoical, but Irish patients suppressed doubts and concerns that Old Americans did not have. Jews called attention to their pain because of concerns about its implications; Italians did so in order to obtain relief. His accounts of the substantial variety of behavioral pain styles among those patient groups is a vivid lesson in adjusting one's expectations of pain behavior and pain tolerance.

That the lesson has not been mastered has been documented by Cleeland et al. (1994) and Freeman & Payne (2000), who reported that women and minority patients are relatively undertreated for pain. There is of course a tangle of social factors contributing to that particular problem, but it still can be regarded as a matter of how much pain an individual is believed to be able to tolerate.

Antiquated norms uninformed by modern pain assessment and treatment techniques have created an environment in which patients are forced to tolerate more pain than is necessary. Much of that undertreatment for pain is directly related to its link to opioid medications, which must be prescribed with care. Excessive administration of opioid medications can result in depressed respiratory and gastrointestinal functioning, as well as disoriented cognition. In addition, the drug dependence which commonly results from recreational use of opioid drugs has created a bias in the culture at large against their use.

A denouncement of the prevalence of insufficiently managed pain, in part due insufficient use of opioid medications, was reflected in a report by the Quality Care Committee of the American Pain Society (1995), and in an urgent call by the American Pain Foundation (2000) for attention to a rampant "epidemic of untreated pain." The growing awareness finally reached critical mass only recently, and the medical community has now witnessed extraordinary changes in how pain is regarded. New sweeping requirements for the monitoring and treatment of pain by the Joint Commission on Accreditation of Healthcare Organizations (2001) is a vivid demonstration of how assumptions and norms can be all wrong and of how little pain tolerance is understood.

III. Background

A. General Background:

1) Theory

Our limited understanding of pain tolerance is in no small part due to our limited understanding of pain itself. Pain is not a simple unitary sensation; it is an amalgam of sensory, affective, cognitive, and other components, which are typically at best only tentatively separable (Gracely, 1992; Fernandez & Turk, 1992; Clark, 2001; Clark et al., 2001). It varies in intensity but also in sensory and emotional quality, and is influenced by expectations and meaning. The definition offered by the International Association for the Study of Pain, "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" (Merskey and Bogduk, 1994), does not begin to capture its complexity.

While the multidimensional complexity of pain may have always been acknowledged anecdotally, its formal recognition is relatively recent. The Aristotelian conception of pain as a "passion of the soul" gave way two millennia later to the mechanistic model of Decartes, which stimulated the evolution of biomedical reductionism. The conception of pain as a simple specific event which traveled along a discrete channel to the brain where it was perceived, persisted for centuries.

Then, in 1965, Melzack and Wall (1965) published their gate theory of pain, which postulated an interaction between signals from neurons, such that nociceptive input could be blocked by input from larger-diameter fibers at the level of the spinal cord. This interactionist perspective led to the elaboration of a model which included both ascending (toward the brain) and descending (from the brain) control of nociceptive transmission in the central nervous system, and hence provided a neurological substrate for the insistence by Sir Charles Sherrington (1900) that pain had both a sensory and an affective dimension.

The role of the brain was further articulated in psychological terms as a tridimensional model of pain, formulated by Melzack and Casey in 1968. Their three dimensions, Sensory-Discriminative, Affective-Motivational, and Cognitive-Evaluative, define the model which remains the dominant influence on current conceptualizations of pain phenomena by most researchers in the field (Gatchel & Turk, 1999; Price, 1999).

2) Empirical Methods

Given the complexity of the experience of pain, some have argued that the study of pain under the precisely controlled and artificial conditions in the laboratory is of limited utility in drawing conclusions about "real" clinical pain (Beecher, 1959; Chapman, 1983; Berkley, 1997). However, responses to clinical pain cannot be analyzed using sophisticated psychophysical techniques. That laboratory and clinical studies confer different advantages is not a new notion, and others (Edens & Gil, 1995; Harkins et al., 1989) have demonstrated that the information gleaned in the laboratory does generalize and has practical as well as theoretical import.

a) Laboratory Pain Induction Techniques

Laboratory pain modalities include heat, cold, electrical, pressure, pinch, ischemic, and chemical stimuli. Presentation can be either of the calibrated discrete type or the continuous cumulative type. Calibrated discrete presentation protocols, often used with heat or electrical stimuli, entail multiple presentations of brief (seconds) randomized intensities. Continuous cumulative presentation protocols entail a persistent (minutes) fixed level of stimulation, such as cold or ischemic constriction, until elective termination by the participant ("pain tolerance time," discussed in the next section) or some designated maximum duration.

The calibrated discrete procedure produces data that can be analyzed using psychophysical models such as Sensory Decision Theory, information that cannot be reliably calculated from continuous presentation protocol data. However, the slow, aching character of continuous pain induction makes it a closer analog of clinical pain, and continuous pain protocols are often favored for that reason.

The Cold Pressor Test

One commonly used continuous pain induction method is the cold pressor test, which involves the exposure of a part of the body to cold water. Because it is easy to standardize, the water is usually prepared by mixing it with ice. Because of convenience, a hand or arm is typically immersed, but stimulation has also been applied to the forehead or foot.

Originally employed as a method to increase blood pressure in the laboratory (Hines & Brown, 1932), the cold pressor test has been favored as a laboratory pain method because it is uncomplicated, standardized, and produced a "natural" pain (Lovallo, 1975).

An unusual feature of the differences in cold pressor pain tolerance time among individuals was mentioned by Davidson and McDougall (1969b), who mused that "no previous studies seem to have been concerned with the problem of an abnormal distribution of cold tolerance scores. It was found in this study that cold tolerance scores were highly positively skewed indicating a few highly extreme scores, whereas the other pain stimulus scores showed a more normal distribution." The replicability of this finding was documented by Chen et al. (1989), who presented data from six studies of Cold pressor pain which demonstrated two non-overlapping distributions: "pain-tolerant" individuals who could tolerate a minimum of 3 minutes of stimulation, and "pain-sensitive" individuals who could tolerate only an average of one minute, with a maximum of 90 seconds.

This group dichotomy has been confirmed by Spanos et al. (1983), Geisser et al. (1992), Lautenbacher et al. (1995). Furthermore, Janal et al. (1994) and Lautenbacher et al. replicated the finding of Davidson and McDougall (1969b) that the dichotimization of participants using the cold pressor was not produced using electrical, thermal, or ischemic pain induction techniques. The ability to study naturally occurring distinct groups makes cold pressor stimulation unusually valuable as a means of studying pain tolerance.

The nomenclature which Chen adopted, that is, pain-tolerant versus pain-sensitive, was misleading, because sensitive refers to sensitivity while tolerance refers to behavior. For this reason, pain-tolerant individuals will continue to be referred to as such, but pain-intolerant individuals will be referred to as pain-intolerant, not pain-sensitive.

b) Pain Measurement Techniques

The measurement of pain, which is subject to a host of psychological variables, remains a challenge. Attempts to find physiological indices of pain, including nociceptive reflexes (Willer, 1983), evoked potentials, (Chen, 1989a), and a series of recent brain-imaging studies (Casey & Bushnell, 2000), have produced interesting results which nonetheless do not constitute an objective measure of pain. Verbal report continues to be acknowledged as the most valid pain response variable available(Gracely & Wolskee, 1983; Gracely, 1992; Clark, 2001). Fortunately, as with other sensory modalities, verbal reports of pain can be analyzed using the techniques of psychophysics and scaling. (Chapman et al., 1985; Gracely, 1992; Clark, 2001).

i) Psychophysical Scaling: Thresholds and Stimulus-Response Functions

A) Thresholds

One operational measure of pain is the pain detection threshold, usually abbreviated to pain threshold, which is the minimum stimulation intensity at which pain is detected. Another frequently measured variable is the pain tolerance threshold, commonly abbreviated to pain tolerance, corresponding to the level of stimulation which produces a behavioral response resulting in termination of the stimulus, either by verbal request or withdrawal. In cold pressor protocols, pain threshold is the time between immersion and the time pain is first reported; tolerance is the time between immersion and withdrawal of the hand (or arm, or foot) from the water bath.

Pain threshold and pain tolerance have often been demonstrated to be poorly correlated. It is widely considered (Sternbach, 1975; Wolf, 1980; Turk & Flor, 1999) that pain threshold is the more stable measure and better indexes sensory functioning, while tolerance is more subject to a host of non-sensory psychological (cognitive and affective) factors. For that reason it manifests considerably greater variability and response to psychological manipulation. (Clark, 1969; 1994), however, accumulated considerable evidence to demonstrate that thresholds, while not as variable as tolerance levels, are more confounded by psychological factors than other authors assumed.)

Another variable which once received attention is the pain range (Wolf, 1980) the difference between threshold and tolerance times. Although the pain range has not proven to be an especially useful index, it does represent the acknowledgment that data beyond pain threshold and tolerance are a potential source of information.

B) Stimulus-Response Functions

Psychophysical scaling is a method of expressing response magnitude as a function of stimulus intensity. The relationship is typically graphed with stimulus intensity on the abscissa and response magnitude on the ordinate. Stimuli are quantified in the appropriate physical units, such as grams, volts, seconds, or degrees Centigrade. Responses can be graded verbal descriptors, numbers, or visual analog scale line segment lengths. Numerical ratings of cold pressor pain over time by pain-tolerant and pain-intolerant (called pain-sensitive) individuals are depicted in Figure 1 (Geisser et al., 1992).

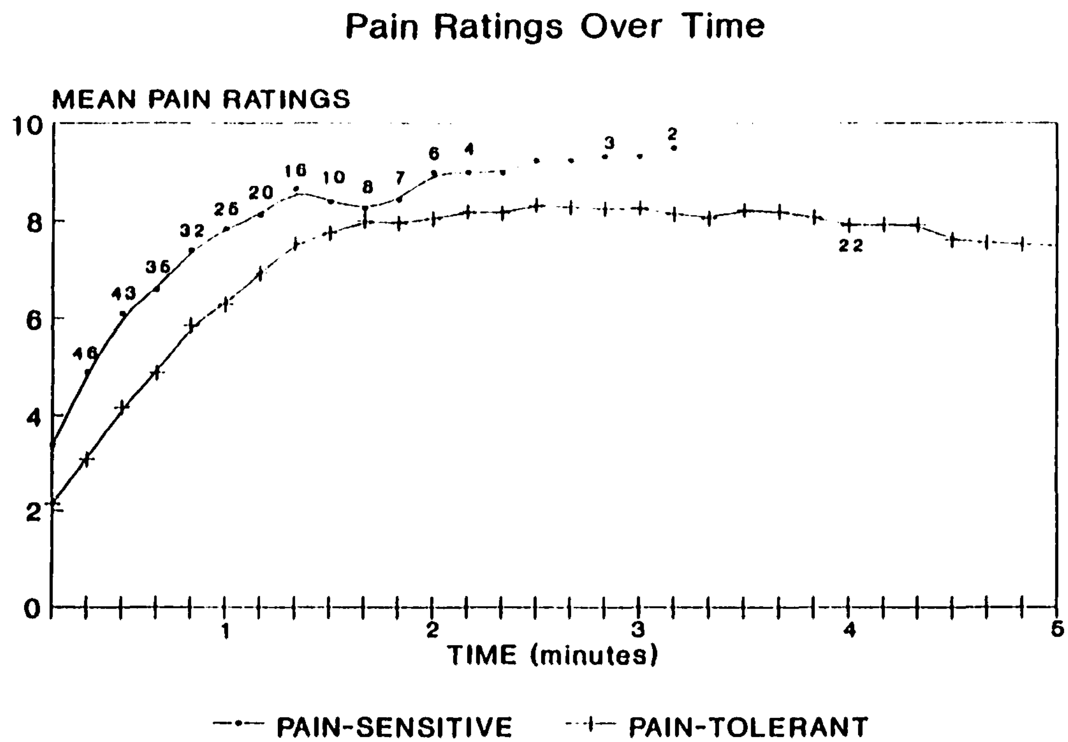


Figure 1. Mean verbal pain ratings of "pain-sensitive" and pain-tolerant participants over time in response to cold pressor stimulation. A change in the number of subjects is noted at each data point. (After Geisser et al., 1992).

Verbal Response Scales

Verbal rating scales for pain (e.g., *mild, moderate, severe*) are commonly used both clinically and in research (Chapman et al., 1985; Gracely, 1992; Clark et al., 2001). Although concern has been raised about the influence of individual differences on the metric stability of words in verbal scales, Gracely et al. (1978a), and Duncan et al. (1989) demonstrated that words can closely approximate ratio estimates. Gracely et al. (1978b) found that verbal descriptor scales were actually more sensitive than numerical in judgments of electrocutaneous dental stimulation, and Duncan et al. found that they were more sensitive than visual analog scales in judgments of heat stimuli.

In addition, as Duncan et al. (1989) pointed out, pain descriptors serve to focus the participant on the attribute of interest. This feature is particularly important when measuring pain. Just as a pain detection threshold corresponds to a particular qualitative perceptual shift (Clark & Goodman, 1974), there are more sensory categories than simply those which correspond to pain threshold and pain tolerance. How is pain graded once it is detected? When does faint pain become moderate pain, or severe pain?

Such questions can be addressed directly by using a verbal pain scale with ordered terms that describes innocuous levels of sensation in the lower half of the scale and painful levels in the upper half. Such a scale serves to focus attention and elicit more meaningful responses than a single-dimensional numerical or visual analog scale.

Janal et al. (1994) demonstrated the value of using an ordered verbal scale. They found that in response to cold pressor stimulation, latencies to report VERY COLD, FAINT PAIN, and MODERATE PAIN, but not COLD, SEVERE PAIN, or withdrawal (tolerance), were significantly greater for runners relative to sedentary controls. The authors concluded that the rigors of athletic training reduced the sensitivity of runners to cold and to pain, but not excessive pain. Responses in the form of simple numbers would not have permitted this interpretation.

Conversely, interpretation of numerical pain ratings must be exercised with caution. Clark et al. (2001) demonstrated that in a sample of cancer surgery patients, numerical pain ratings were significantly predicted by Multidimensional Affect and Pain Survey affective ratings of depressed mood, fear, anxiety, and anger, but not by any sensory ratings.

Nevertheless, the simplicity of numbers has continued appeal for some applications. Numerical responses can be expressed using direct scaling, that is, directly proportional to the perceived magnitude of the stimulus (such as on a scale of 1 to 10), or as some ratio of a set standard (such as a value of 100), called a *modulus*. The latter ratio scaling method has been used extensively in studies of pain by Gracely (1992) and Price et al. (1994), among others.

Advantages of a ratio scaling protocol include a (logarithmically transformed) data set which is conveniently summarized as a linear function and the avoidance of a response compression ("ceiling effect") at higher intensities, since the upper end of the scale is unbounded.

Limitations of the ratio scaling procedure include the requirement of abstract reasoning demanded for calculations based on a modulus, and the inability of single numbers to indicate the occurrence of response shifts such as the occurrence of pain or incrementation of pain.

Consider cold pressor stimulation, which typically begins with sensations of increasing cold, followed by the emergence and growth of pain with some consequent emotion.

Since the latencies at which these various components begin and their relative magnitudes vary among individuals, it is difficult to appreciate how an immersion of a standard duration (intensity) can serve as a modulus.

To illustrate, in a protocol employed by Stam et al. (1981) and Spanos et al. (1983), a 10 second immersion served as the modulus. Since 10 seconds may not even be enough time to elicit a report of cold, let alone pain, one must infer that participants in these studies used different moduli (some cool, some cold, some painful, some excruciating) to make their comparative judgments, resulting in a collection of measurements based on different calibrations.

That Spanos et al. (1983), Stam et al. (1981), Gracely et al. (1978a,b) and others have reported meaningful results using ratio scaling protocols suggests that participants are somehow able to distill their aggregate experience into a single numerical index (usually of "intensity" or "unpleasantness"). However, the distillation of sensory, affective and cognitive components into a single number renders them indistinguishable.

ii) Questionnaires

A) The Multidimensional Affect and Pain Survey

To better model and measure the multiple dimensions of pain, Clark et al. (1989) argued that "multidimensional pain requires multidimensional scaling", a data reduction technique which is used to analyze proximities, or psychological distances, among physical or verbal stimuli (Clark, 1984). Proximities are most commonly derived from judged similarities among stimuli in the form of numerical ratings, but can also be derived from covariances or correlations.

In a series of studies, Clark (1984, 1996) and Clark et al. (1986, 1989, 2001) introduced the application of multidimensional scaling analysis to the study of pain. Using INDSCAL (Carroll & Chang, 1970), or individual differences scaling, a technique which permits the measurement of the salience of dimensions to individual participants, they demonstrated either the existence or relative salience of two to four dimensions underlying the sensory and affective domains of pain and suffering.

Clark et al. (1995) also employed cluster analysis to generate a complementary model which provided additional information about the semantic organization of pain concepts. When employed as a means of pain assessment, the latter model is represented in the Multidimensional Affect and Pain Survey (Appendix 1). As that model served as the basis for testing a set of hypotheses in this study, it is described here in detail.

Clark et al. (2001) presented 104 male and female African-American, Euro-American, and Puerto Rican participants with a set of 189 words. That set had been distilled from a larger set of 270 described by Clark et al. (1995) and asked them first to categorize them into groups of similar items, then to merge them two at a time in order of increasing similarity. Initial group membership and order of merging were quantified as similarity values, which were used to construct a half-matrix of word proximities for each participant. These matrices were analyzed using hierarchical agglomerative average-linkage-between-groups cluster analysis (Sokal & Michener, 1958) to generate the structure represented by the dendrogram in Figure 2, characterized by thirty clusters subsumed under three superclusters: (I) Somatosensory Qualities, (II) Emotional Qualities, and (III) Well-Being.

1) Features of the Cluster Model

The initial major semantic distinction demonstrated by the cluster structure is the division between negative

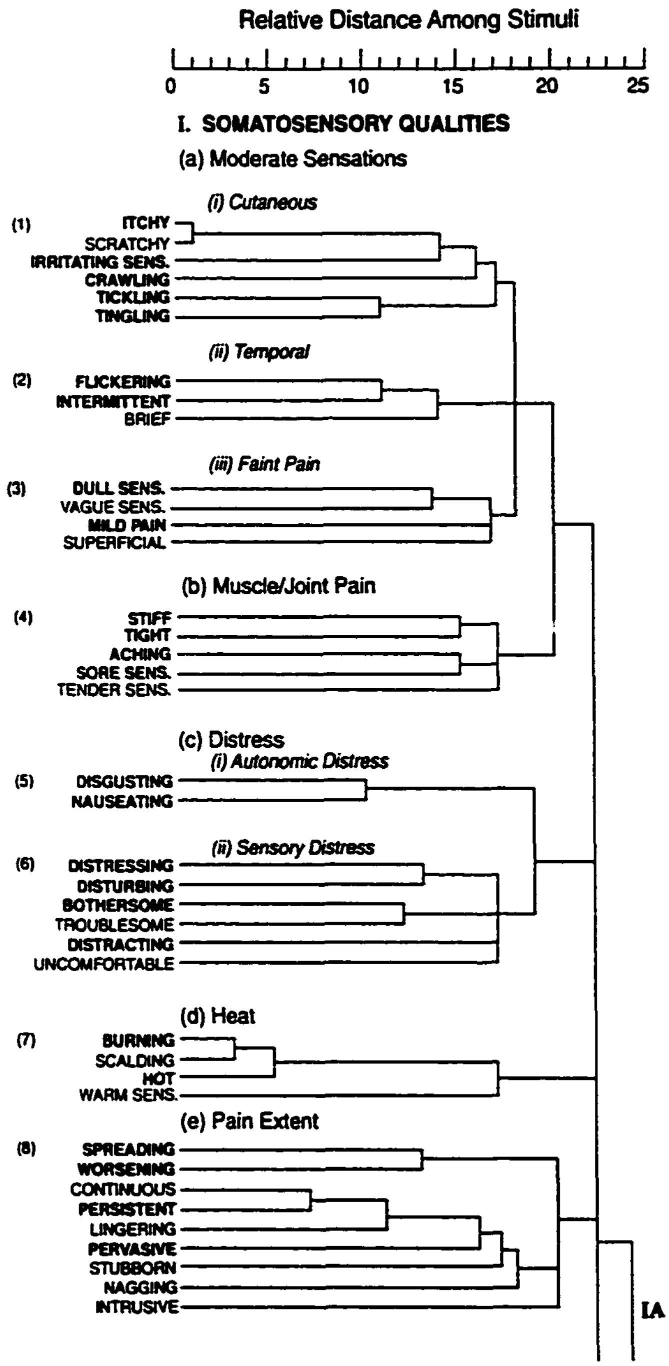
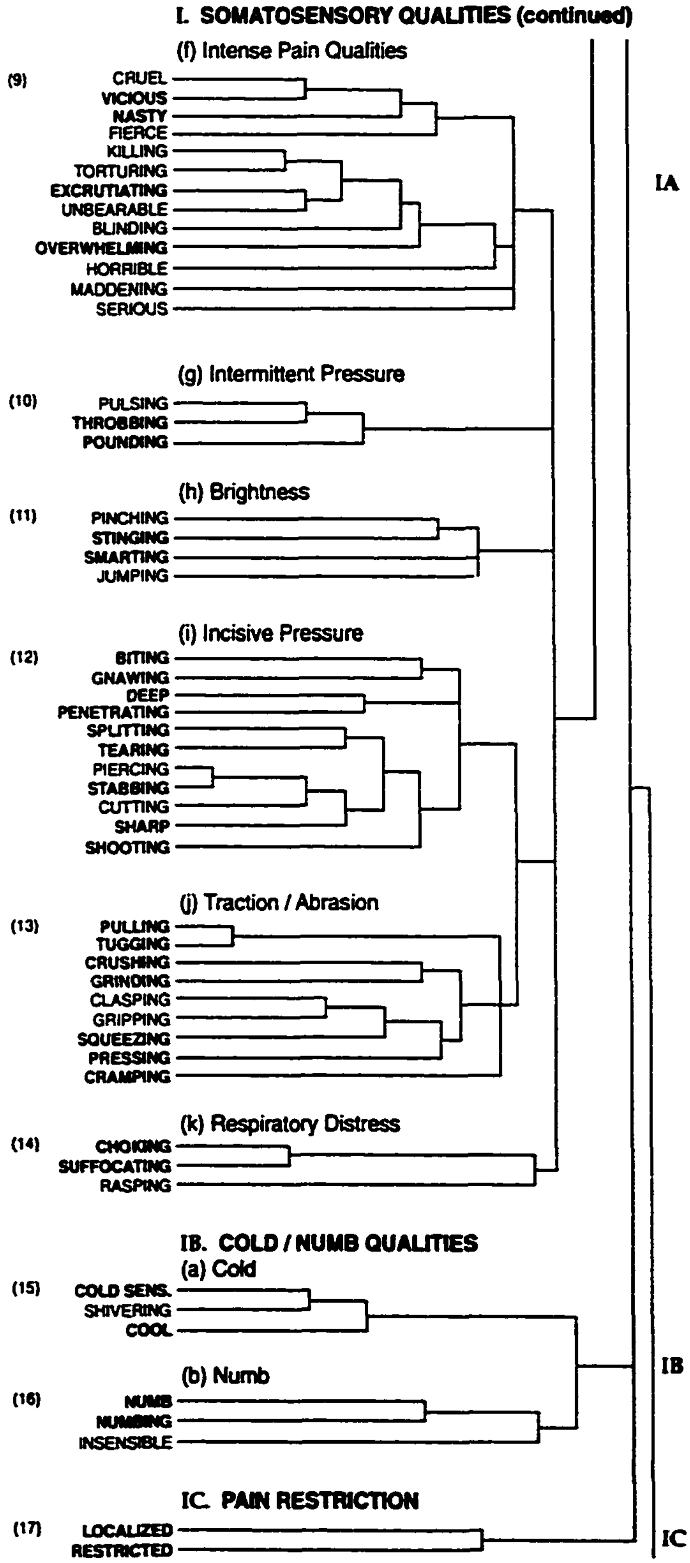
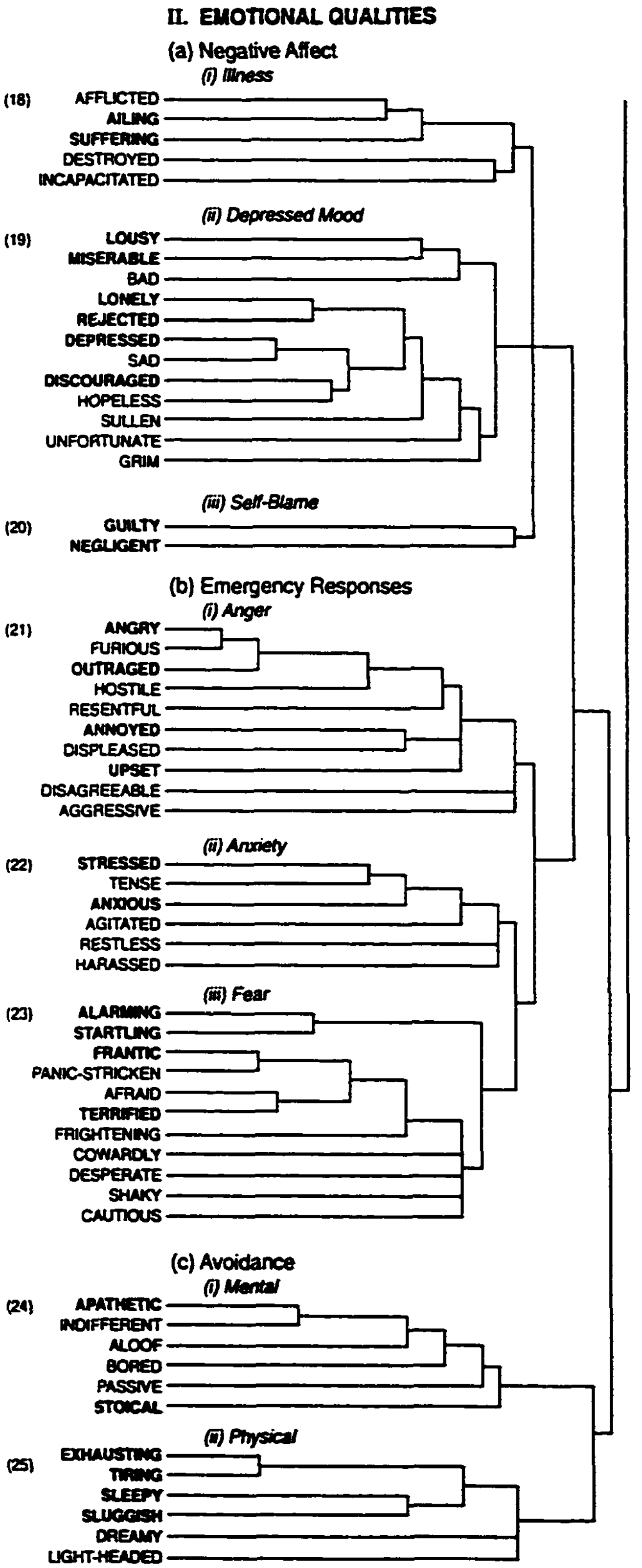
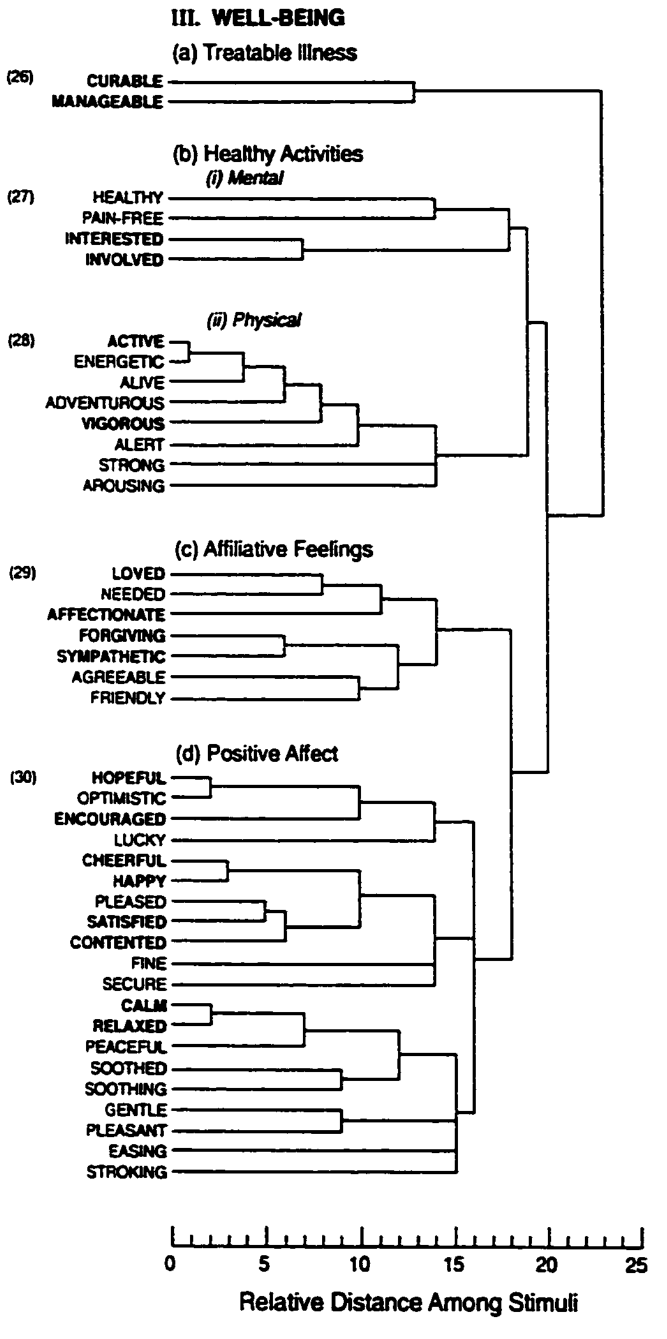


Figure 4. Dendrogram produced by cluster analysis of similarity ratings among 189 words made by 104 male and female African American, Euro-American, and Puerto Rican participants, on which the Multidimensional Affect and Pain Survey is based (Clark et al., 2001).


I. SOMATOSENSORY QUALITIES (continued)
(f) Intense Pain Qualities
(9)
CRUEL
VICIOUS
NASTY
FIERCE
KILLING
TORTURING
EXCRUTIATING
UNBEARABLE
BLINDING
OVERWHELMING
HORRIBLE
MADDENING
SERIOUS
(g) Intermittent Pressure
(10)
PULSING
THROBBING
POUNDING
(h) Brightness
(11)
PINCHING
STINGING
SMARTING
JUMPING
(i) Incisive Pressure
(12)
BITING
GNAWING
DEEP
PENETRATING
SPLITTING
TEARING
PIERCING
STABBING
CUTTING
SHARP
SHOOTING
(j) Traction / Abrasion
(13)
PULLING
TUGGING
CRUSHING
GRINDING
CLASPING
GRIPPING
SQUEEZING
PRESSING
CRAMPING
(k) Respiratory Distress
(14)
CHOKING
SUFFOCATING
RASPING
IB. COLD / NUMB QUALITIES
(a) Cold
(15)
COLD SENS.
SHIVERING
COOL
(b) Numb
(16)
NUMB
NUMBING
INSENSIBLE
IC. PAIN RESTRICTION
(17)
LOCALIZED
RESTRICTED
IA
IB
IC


II. EMOTIONAL QUALITIES
(a) Negative Affect
(i) Illness
(18)
AFFLICTED
AILING
SUFFERING
DESTROYED
INCAPACITATED
(ii) Depressed Mood
(19)
LOUSY
MISERABLE
BAD
LONELY
REJECTED
DEPRESSED
SAD
DISCOURAGED
HOPELESS
SULLEN
UNFORTUNATE
GRIM
(iii) Self-Blame
(20)
GUILTY
NEGLIGENT
(b) Emergency Responses
(i) Anger
(21)
ANGRY
FURIOUS
OUTRAGED
HOSTILE
RESENTFUL
ANNOYED
DISPLEASED
UPSET
DISAGREEABLE
AGGRESSIVE
(ii) Anxiety
(22)
STRESSED
TENSE
ANXIOUS
AGITATED
RESTLESS
HARASSED
(iii) Fear
(23)
ALARMING
STARTLING
FRANTIC
PANIC-STRICKEN
AFRAID
TERRIFIED
FRIGHTENING
COWARDLY
DESPERATE
SHAKY
CAUTIOUS
(c) Avoidance
(i) Mental
(24)
APATHETIC
INDIFFERENT
ALOOF
BORED
PASSIVE
STOICAL
(ii) Physical
(25)
EXHAUSTING
TIRING
SLEEPY
SLUGGISH
DREAMY
LIGHT-HEADED



III. WELL-BEING
(a) Treatable Illness
(26)
CURABLE
MANAGEABLE
(b) Healthy Activities
(i) Mental
(27)
HEALTHY
PAIN-FREE
INTERESTED
INVOLVED
(ii) Physical
(28)
ACTIVE
ENERGETIC
ALIVE
ADVENTUROUS
VIGOROUS
ALERT
STRONG
AROUSING
(c) Affiliative Feelings
(29)
LOVED
NEEDED
AFFECTIONATE
FORGIVING
SYMPATHETIC
AGREEABLE
FRIENDLY
(d) Positive Affect
(30)
HOPEFUL
OPTIMISTIC
ENCOURAGED
LUCKY
CHEERFUL
HAPPY
PLEASED
SATISFIED
CONTENTED
FINE
SECURE
CALM
RELAXED
PEACEFUL
SOOTHED
SOOTHING
GENTLE
PLEASANT
EASING
STROKING
0
5
10
15
20
25
Relative Distance Among Stimuli

(I: Sensory Qualities + II: Emotional Qualities) and positive (III: Well-Being). The negative words are divided into those describing (I)the sensory aspects of pain, and those describing (II) the emotional aspects of suffering.

The Somatosensory Qualities supercluster comprises three groups. The first group (IA) divides into two subgroups that differ overall in both pain qualities and energy level. The first subgroup contains generally more superficial and/or less intense descriptors. Included are the (a) Moderate Sensations cluster triad *Cutaneous, Temporal,* and *Faint Pain,* linked to (b) *Muscle/Joint Pain,* the (c) Distress dyad, *Autonomic* and *Sensory,* and the (d) *Heat* and (e) *Pain Extent* clusters. The second subgroup contains generally deeper and/or more intense descriptors, including the clusters (f) *Intense Pain Qualities,* (g) *Intermittent Pressure,* and (h) *Brightness,* the dyad (i) *Incisive Pressure* and (j) *Traction/Abrasion,* and the(k) *Respiratory Distress* cluster. The second group (IB) comprises the dyad (a) *Cold* and (b) *Numb,* and the third group (IC) consists of the single cluster *Pain Restriction.*

The Emotional Qualities supercluster (II) also comprises two groups. The first comprises the (a) Negative Affect cluster triad *Illness, Depressed Mood,* and *Self-*

Blame, and the (b) Emergency Response clusters, *Anger* and the dyad *Anxiety* and *Fear*. The second group comprises a single dyad, the (c) *Mental* and *Physical* Avoidance clusters.

The Well-Being supercluster (III) splits off the extremely small (a) *Treatable Illness* cluster from the remainder, which is divided into two subgroups. One subgroup is the (b) *Mental* and *Physical* Healthy Activities cluster dyad; the other subgroup comprises the cluster dyad (c) *Affiliative Feelings* and (d) *Positive Affect*.

When using the Multidimensional Affect and Pain Survey (Appendix 1)for pain measurement, participants rate their pain, sensation or state using each word contained in an appropriate sentence on a numerical scale (typically 0 to 5; 0 to 9 in this study). Mean ratings of words in the 30 clusters are calculated, as are 3 supercluster means of cluster means. There are two principal versions: the full 189-word set and a 101-word subset including only those descriptors which were classified similarly by respondents irrespective of their gender or ethnicity.

2) Reliability and Validity of the Model

The cluster structure, using a subset of 98 descriptors, has been replicated by Fletcher (1996). The utility of the model has been demonstrated using the shorter 101-word version. Kuhl et al. (1995) demonstrated the validity of the Multidimensional Affect and Pain Survey by comparing response profiles for cold pressor and contact heat stimulation. Mean cluster scores for 20 of 30 clusters and all 3 superclusters were significantly different in the expected directions. Guastadisegni et al. (1996) used the Multidimensional Affect and Pain Survey to characterize the burning itching pain of postherpetic neuralgia, and Winer (1998) to profile the aching and dread of cancer pain. Yang et al. (2000) demonstrated the relative importance of pain affect, rather than pain sensation, in predicting morphine usage in post-surgical patients.

The principal advantages of the Multidimensional Affect and Pain Survey are its objective construction based on conceptualizations by a sample of healthy volunteers rather than the *a priori* notion of an investigator, and, as is evident from Figure 2, its broad coverage of the range of sensory, evaluative, and affective (including positive) responses to pain.

Positive terms were included for two reasons. First, it is important to include widely disparate concepts in a stimulus set when attempting to identify the dimensions which define a conceptual space (Clark, 1984), such as that of pain and suffering. Secondly, the extent to which pain tolerance may be in part attributable to a difference in "positive responses" to pain has gone largely uninvestigated, except insofar as it affects coping with clinical pain (Keefe & Gil, 1986; Boothby et al., 1999). That a euthymic dimension of pain has not typically been intuitively relevant is consistent with the position of Folkman and Moskowitz (2000), who pointed out that our knowledge of coping with stress in general is limited by our relative neglect of the study of relevant positive affect. Wharton (personal communication) has observed higher-functioning psychiatric patients who paradoxically indicate that they are both happy and depressed.

B) The McGill Pain Questionnaire

After Melzack and Casey (1968) proposed the model distinguishing the sensory-discriminative, affective-motivational, and cognitive-evaluative dimensions of pain, Melzack developed the McGill Pain Questionnaire (1975; Figure 3), a 93-item list of words which subsumes 20 subgroups under 3 major groups: Sensory, Affective, and Evaluative, in addition to one separate group describing temporal qualities, and another separate group, ordered on a scale, which one uses to rate a Present Pain Intensity.

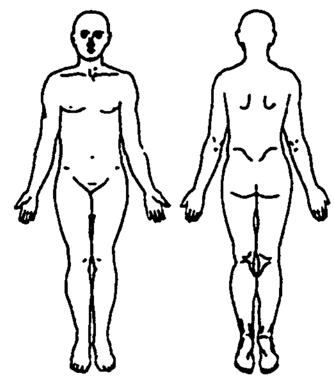
McGill Pain Questionnaire

Patient's Name ________ Date ________ Time ________ am/pm

PRI: S ______ (1-10) A ______ (11-15) E ______ (16) M ______ (17-20) PRI(T) ______ (1-20) PPI ______

1 FLICKERING QUIVERING PULSING THROBBING BEATING POUNDING	11 TIRING EXHAUSTING
2 JUMPING FLASHING SHOOTING	12 SICKENING SUFFOCATING
3 PRICKING BORING DRILLING STABBING LANCINATING	13 FEARFUL FRIGHTFUL TERRIFYING
4 SHARP CUTTING LACERATING	14 PUNISHING GRUELLING CRUEL VICIOUS KILLING
5 PINCHING PRESSING GNAWING CRAMPING CRUSHING	15 WRETCHED BLINDING
6 TUGGING PULLING WRENCHING	16 ANNOYING TROUBLESOME MISERABLE INTENSE UNBEARABLE
7 HOT BURNING SCALDING SEARING	17 SPREADING RADIATING PENETRATING PIERCING
8 TINGLING ITCHY SMARTING STINGING	18 TIGHT NUMB DRAWING SQUEEZING TEARING
9 DULL SORE HURTING ACHING HEAVY	19 COOL COLD FREEZING
10 TENDER TAUT RASPING SPLITTING	20 NAGGING NAUSEATING AGONIZING DREADFUL TORTURING
	PPI 0 NO PAIN 1 MILD 2 DISCOMFORTING 3 DISTRESSING 4 HORRIBLE 5 EXCRUCIATING

BRIEF MOMENTARY TRANSIENT	RHYTHMIC PERIODIC INTERMITTENT	CONTINUOUS STEADY CONSTANT



E = EXTERNAL
I = INTERNAL

COMMENTS:

Figure 3. The McGill Pain Questionnaire. The descriptors fall into four major groups: sensory, 1 to 10; affective, 11 to 15; evaluative, 16; and miscellaneous, 17 to 20. The rank value for each descriptor is based on its position in the word set. The sum of the rank values is the pain rating index. The present pain intensity is based on a scale of 0 to 5. Copyright 1970 Ronald Melzack.

These words had been selected, categorized, and ordered by Melzack and collaborators in an attempt to cover the spectrum of pain and suffering (Melzack & Torgerson, 1971).

A number of studies have replicated and validated the McGill Pain Questionnaire. Reading et al. (1982) used cluster analysis of similarity ratings by 90 participants of the McGill Pain Questionnaire words to generate a cluster structure that, with some exceptions, strongly resembled the original categorization scheme. The exceptions, in fact, seemed to constitute improvements. For example, *sickening* clustered with *nauseating* rather than *suffocating*, and *wretched* clustered with *miserable* rather than *blinding*.

Results of other cluster analytic studies have been mixed. Verkes et al. (1989) used multidimensional scaling to analyze similarity ratings of a set of 176 Dutch words, including the translated McGill Pain Questionnaire, and found a structure resembling the original (although the resemblance was not as striking as in the study by Reading et al., 1982). However, using a different mathematical procedure, Kwilosz et al. (1983) cluster analyzed proximities based on participant group sortings (but not merging) of pain descriptors, many of which were words from the McGill Pain Questionnaire. Those authors found rampant discordance between that empirical cluster structure of those terms and the McGill Pain Questionnaire classification.

Studies attempting to confirm the factor structure of the McGill Pain Questionnaire have produced mixed results (Turk et al., 1985). Clark et al. (1995), using cluster analysis, demonstrated the considerable heterogeneity of items within McGill Pain Questionnaire groups (particularly the Evaluative group) by comparing their placements in McGill Pain Questionnaire groups with those in Multidimensional Affect and Pain Survey clusters.

A serious problem with the McGill Pain Questionnaire is that the putative rank order of the words (according to intensity) in each (multidimensional) list is not consistently obvious. Although the rankings were calculated based on numerical ratings by physicians, students, and patients (Melzack & Torgerson, 1971), there are instances where the semantic relatedness of the words in a group appears somewhat contrived (e.g., *wretched* and *blinding; tender, taut, rasping,* and *splitting*). The problem is compounded because respondents are instructed to select the one word which best represents their experience, and that word is scored based on its rank order. However, since the words are often qualitatively different, their ranking as if on a single dimension is questionable. Is *lancinating* actually greater than *stabbing* which is greater than *drilling*? Is *heavy* greater than *aching* which is greater than *hurting*? Why is *suffocating* greater that *sickening*? This last comparison constitutes a particularly problematic example. If the cold pressor causes one person to experience mild difficulty breathing and another person considerable nausea, the score of the first person will still be higher simply because of the kind of sensation, not its intensity.

The semantic heterogeneity of words within groups illustrates the flawed structure of the McGill Pain Questionnaire (Clark, 1995). The structure of the Multidimensional Affect and Pain Questionnaire, however, by virtue of being objectively derived from the judgments of participants, does not suffer from any linguistic prejudice.

The other advantages of the Multidimensional Affect and Pain Survey relative to the McGill Pain Questionnaire are a considerably greater representation of the variety of affective terms and the inclusion of positive descriptors.

3) The Influence of Traits

a) Stability of Pain Response Style

How stable a trait is pain tolerance? How indicative are pain responses observed in the laboratory of a general pain response style? Although there is certainly variability among individuals attributable to the kind (Janal et al., 1994; Lautenbacher et al., 1995; Rainville et al., 1992) and circumstances (Beecher, 1959) of painful stimulation, some part of the variance in pain response is attributable to the individual. To best evaluate the effect of individual differences, one would need to gather data about as many different painful events as possible. While not impossible to do in the laboratory, there is also a wealth of information to be derived from accounts of events outside the lab.

Investigational methods involving retrospective report have unquestionable limitations. Nevertheless, opportunities to conduct longitudinal observational studies are relatively rare, can be difficult to implement, and require substantial commitments of time and resources. Furthermore, while the control in the laboratory is lost when inquiring about events in the field, sufficient numbers of stimuli and participants may permit differences between groups to be confirmed, although positive findings to demonstrate that are limited.

Brattberg et al. (1988), Schalling (1970), and Schalling et al. (1970) advocated the use of inventories of past painful events to provide information about general pain response style. Brattberg collected numerical pain intensity data in response to a short list of events ranging from mosquito bites to broken legs from a sample of healthy volunteers in Sweden, but did not compare those data to actual pain data. Schalling and Schalling et al. did compare responses to reported experiences of painful events and experimental pain data using the Situational Unpleasantness Susceptibility Inventory (Schalling & Levander, 1964), but did not find a relationship.

To assess responses to painful events outside the laboratory, Clark (cited in Yang et al., 1983) developed the Situational Pain Questionnaire, a list of more and less painful events which participants respond with numerical pain ratings, on the basis of their experience or imagination. The Situational Pain Questionnaire was devised to evaluate one's discriminative capacity, that is, the ability to distinguish more painful from less painful events, and response bias, that is, the general proclivity to call events more or less painful.

According to the non-parametric Sensory Decision Theory model, discrimination between more and less intense stimuli is indexed by *P(A)*, the area under the Receiver Operating Characteristic curve, a plot of hits (affirmative responses to signals) on the ordinate and false affirmatives (affirmative responses to noise) on the abscissa. High values of *P(A)* reflect superior discrimination. Response bias is indexed by *B*, the median response category. Response categories are reverse-ordered: the lowest ordinal rank corresponds to the highest response magnitude, so that the higher the value of *B*, the higher the criterion for reporting pain. Russ et al. (1996) used the Situational Pain Questionnaire to demonstrate that patients with borderline personality who did not feel pain when they injured themselves demonstrated poorer discrimination than those who did feel pain, and further that their poorer discrimination correlated with poorer discrimination of laboratory phasic heat pain stimuli.

A variation of the Situational Pain Questionnaire is the Experienced Pain Questionnaire (Appendix 2). On the Experienced Pain Questionnaire, participants are asked to respond only to events that they have experienced. The 48 events range from mosquito bites to heart attacks, and the responses are graded verbal responses: NONE MILD MODERATE SEVERE. *P(A)* and *B* are calculated based on the relative proportions of higher pain ratings assigned to higher-intensity stimuli ("signals") and lower-intensity stimuli ("blanks").

b) Anxiety

The relationship between pain and personality traits has been the subject of extensive investigation, with the majority of studies focused on traits with pronounced affective dimensions: depression, hostility, extraversion, and especially neuroticism and anxiety (Suinn, 2001; Weisberg & Keefe, 1999; Schalling, 1985; Geisser et al., 1994; Harkins et al., 1989). Overall, the evidence has supported the notion that individuals who are prone to experiencing enhanced negative emotions are also more prone to report higher levels of pain.

Many of the reports regarding the influence of anxiety come from clinical venues. Wade et al. (1992) reported that VAS anxiety was the best predictor of clinical pain behavior in a mixed population of chronic pain patients, composed principally of those with low back pain, myofascial pain disorder, and sympathetically maintained pain. Harkins et al. (1989) also found greater negative affect (but not greater negative sensation) among higher-neuroticism patients with myofascial pain disorder, regarding both their myofascial pain and experimental heat pain. Ellington and Wiebe (1999) found that even healthy individuals with higher levels of neuroticism reported both greater negative sensory and emotional experiences when they *role-played* patients with clinical pain syndromes.

In experimental studies, there has been inconsistency in findings regarding the relationship between pain and anxiety due to the variety of methods employed to assess and/or produce pain, and to assess and/or to produce anxiety. For instance, Bobey and Davidson (1970) found that anxiety induced in female participants who listened to a tape of a woman in labor *increased* tolerance to laboratory heat and pressure pain. Frid et al. (1979) found a similar positive relationship between S-R anxiety (Endler et al., 1962) and tolerance for forearm ischemic pain. However, in another report in the same year, Frid and Singer (1979) found a positive relationship between ischemia tolerance and STAI State Anxiety, but an *inverse* relationship with S-R anxiety.

As central a role that anxiety has played in trying to understand the relationship between pain and emotion, it is as a construct both too specific and too general. On the one hand, Clark and Watson (1991), Williams et al. (1992), and Allred and Smith (1989) have suggested that anxiety, depression, and "maladjustment" are so intercorrelated in a non-clinical population that drawing fine distinctions between subcomponents of negative affectivity is inappropriate, and that one ought go no farther than to index neuroticism or general dysphoria. On the other hand, a number of authors have emphasized that the various forms of anxiety are distinct and need to be acknowledged as such. These include the distinction between state and trait anxiety (Spielberger et al., 1970), and less commonly, between cognitive and somatic anxiety.

Nichols and Tursky (1967) attempted to demonstrate the specific effect of somatic ("body") anxiety on electrical pain in 30 male college students. They did not find an effect, and concluded that their methods, including the Rorschach test and the Secord homonym test, designed to elicit bodily associations, might not have been valid. Nevertheless, consistent with the notion that preoccupation with bodily experience by extension sensitizes one to pain, Cloninger (1986) reviewed findings suggesting that somatic anxiety correlated with pain as well a non-painful sensation thresholds, and Schalling

(1985), also in a review, reported summary positive correlations between pain and somatic anxiety.

c) Hardiness

Just as positive dimensions of the experience of pain have been relatively understudied, so have positive traits of those who experience pain. Adaptive *responses* to pain, that is, coping behaviors, have been the subject of investigation, but the personality traits which could serve to ameliorate or make more tolerable painful events have received far less attention.

The hardiness construct assesses positive coping-related proclivities that the originators (Kobasa et al., 1982) believed to buffer adverse emotional responses to stressors and consequently preserve health. Based on existential psychology theory, the three dimensions of hardiness are 1) control, the belief that events are the consequences of one's actions, and not unexpected or overwhelming, 2) commitment, the belief that one is involved with one's circumstances, and a reticence to give up under pressure, and 3) challenge, the belief that change is normal and stimulating, not threatening. The orthogonality of those dimensions has been challenged, and it has also been suggested that hardiness is seriously confounded with neuroticism (Allred & Smith, 1989).

Nevertheless, hardiness has been demonstrated to correlate with positive thoughts and positive self-statements (Allred & Smith) and adaptive coping (Williams, 1992) under stressful conditions. It could therefore be reasonably expected to reflect relatively more positive responses to pain.

However, it must be acknowledged that in the few instances in which the relationship between hardiness and pain been investigated, the expected relationships have not been clearly demonstrated. Okun et al. (1988) found that reported arthritis pain was unrelated to total hardiness or any of the three dimensions. Van Treuren and Hull (1987) found that participants with higher levels of commitment reported less cold pressor discomfort, although there was no effect of any hardiness variable on tolerance time.

These negative results notwithstanding, consider that in a study of responses to the Pain Regulation Questionnaire (Eifert et al., 1995) by a mixed population of chronic pain patients (principally back pain, headache, and joint pain), Schermelleh-Engel et al. (1997) found that perceived competence superseded both STAI Trait anxiety and anxiety as measured by the Pain Regulation Questionnaire. Litt (1988) found that self-efficacy, manipulated by informing participants that their performance on an initial cold pressor trial put them either in an exceptionally high or low population percentile, positively correlated with cold pressor tolerance on the subsequent trial.

A different kind of manipulation was employed by Buss and Portnoy (1967), who demonstrated that implicit challenge increased electrical pain tolerance in their sample of 90 male college students who were informed that their pain tolerance was generally inferior to that of either 1)women, 2)Russians, or 3)students from a rival university. Lambert et al. (1962) demonstrated a similar elevation of pain tolerance in Jewish and Gentile women who were informed that their pain tolerance was generally inferior to that of the other group.

Therefore, despite the negative results of Okun et al. (1988) and of Van Treuren and Hull (1987), there are still compelling conceptual grounds for hypothesizing that pain-tolerant individuals will demonstrate relatively higher control, commitment, and challenge.

B) Specific Background:

1) Previous Studies Of The Pain-Tolerant/ Pain-Intolerant Distinction Among Cold Pressor Responders

a) Dichotomy

As was mentioned earlier, Geisser et al. (1992), Janal et al. (1994), and Lautenbacher et al. (1995) replicated the dichotomized distribution of cold pressor pain tolerance times reported by Chen et al. (1989b). Janal et al. and Lautenbacher et al. further demonstrated that no dichotimization of participants was produced using other pain induction techniques, including electrical, heat and ischemic simulation. The dichotomy was evidenced despite some variability in design (location, number and kinds of subjects, maximum length of immersion).

Chen et al. (1989b) claimed that pain tolerance times of pain-tolerant participants and pain-intolerant participants were defined by non-overlapping distributions. Close inspection of the data from the studies reviewed suggest that one can reasonably expect a mean of 60 to 70 seconds with a SD of 30 to 40 among pain-intolerant participants, although their proportion of the total number of participants is highly variable. The characterization of the tolerance time distributions as non-overlapping is something of an overstatement. Nevertheless, the data do argue for accepting the truncated distributions presented in the studies as replications of the highly positive skew noted by Davidson and McDougall (1969b).

b) Thresholds and Stimulus-Response Functions

Prior to the attention to the report by Chen et al. (1989b), Spanos et al. (1983) used a cold pressor ratio scaling protocol to demonstrate that the cold pressor stimulus-response curve of pain-tolerant participants was significantly less steep than that of pain-intolerant participants, indicating smaller perceived stimulus magnitudes across the range of intensities produced by cumulative cold pressor stimulation.

Chen et al. (1989b) measured both cold pressor pain threshold and pain tolerance. They were presumably interested in whether participants who demonstrated higher pain tolerance would also demonstrate higher pain thresholds, suggesting that pain tolerance might be attributable to a relative pain insensitivity. The noticeable absence of threshold data in that report suggests that no significant difference between groups in pain threshold was found, failing to support any hypothesis regarding sensitivity.

The only other psychophysical data gathered by Chen et al. (1989b) were visual analog scale ratings made after immersion of intensity, anchored by *not at all* and *pain as bad as one can imagine* and aversiveness, anchored at *not at all* and *pain as unpleasant as one can imagine*. Pain-intolerant participants did rate pain intensity as slightly, though significantly, greater than did pain-tolerant participants, but there was no difference between groups in visual analog scale pain aversiveness.

Geisser et al. (1992) gathered numerical cold pressor pain ratings on a 0 (*no pain*) to 10 *(worst possible pain*) scale every 10 seconds, and found that ratings of pain-intolerant participants were lower after every time period than those of pain-tolerant participants, and that pain-tolerant participants had considerably higher pain thresholds than pain-intolerant participants (97 [SD 109] versus 31 [SD 25] seconds).

Lautenbacher et al. (1995) gathered data in two cold pressor trials in order to focus separately on sensory intensity and affective unpleasantness. Participants responded every 20 seconds (3 minute maximum) to a 10 cm visual analog scale (*no pain -- extremely intense pain* or *no pain -- extremely unpleasant pain*). Eight of 18 pain-intolerant participants demonstrated higher scores for both pain intensity and unpleasantness. Pain thresholds were not measured, so no comparisons between groups on that measure of sensitivity can be made.

Studies of differences in pain threshold among pain-tolerant and pain-intolerant individuals are inconsistent. Chen et al. (1989b) reported no threshold data for pain-tolerant participants and pain-intolerant participants, suggesting no difference between groups. Geisser et al. (1992) alone found a considerable difference in thresholds, in the direction consistent with the hypothesis that pain-intolerant participants are more sensitive to pain.

Somewhat more consistency is evident among the rating data from the studies by Spanos et al. (1983), Geisser et al. (1992), and Lautenbacher et al. (1995), which all suggest that there is a perceptual difference between pain-intolerant participants and pain-tolerant participants. Cold pressor pain ratings by pain-intolerant participants were consistently higher than those of pain-tolerant participants, irrespective of the method of measurement.

The ratio scaling protocol used by Spanos et al. (1983) employed as a modulus the amount of pain produced by a 10-second ice water immersion. Since pain is not always produced within the first 10 seconds of immersion, this was a confounded measure. Furthermore, since it is unknown what level of pain, if any, corresponded to the modulus, the numerical responses those authors recorded do not provide information beyond a measure of general intensity. Therefore, although the different slopes presented by those authors suggested a relative perceptual attenuation across the range of stimulus intensities, it is unknown whether that range included non-painful intensities.

Data about non-painful intensity levels are also absent in the studies by Geisser et al. (1992) and Lautenbacher et al. (1995), since the rating scales they used were anchored at the zero point by *no pain*. Visual approximation of the numerical (0-10) data presented in Figure 1 (Geisser et al., 1992) suggest that after only 10 seconds, the mean pain report was 2 for pain-tolerant participants, and 3 for pain-intolerant participants. Inspection of similar figures in the report by Lautenbacher et al. depicts a similar ratio: after 20 seconds, the mean VAS (0-100) pain report was 40 for pain-tolerant participants, and 60 for pain-intolerant participants. In both reports, the stimulus-response curves of the two groups appear to progressively separate as they approach 60 seconds, after which they either remained approximately parallel (Geisser et al., 1992) or reapproached each other (Lautenbacher et al., 1995).

Hence, two questions remain to be answered. The first is how to interpret the meaning of the divergence between the curves depicted. How do the differences translate when responses are verbal reports? The second is whether the demonstrated difference in stimulus-response curves is limited to cold pressor pain, or reflects a more general perceptual difference that includes cold sensations associated with non-noxious levels of stimulation.

c) Questionnaires

Chen et al. (1989b) gathered responses to the McGill Pain Questionnaire following visual analog scale ratings of cold pressor pain intensity and aversiveness. McGill Pain Questionnaire Sensory scores did not differ between groups, but Affective, Evaluative, Miscellaneous and Total, as well as Present Pain Intensity scores, were significantly higher for pain-intolerant participants.

Notice must be taken that these differences only occurred when data were summed across 6 studies resulting in a total number of 205 participants. It did not represent a replicated pattern among studies. Still, those results are not readily reconciled with their visual analog scale data. Recall that Chen et al. (1989b) had administered two visual analog scales designed to independently assess intensity, anchored by *not at all* and *pain as bad as one can imagine,* and aversiveness, anchored by *not at all* and *pain as unpleasant as one can imagine.* There was no difference between groups in pain aversiveness ratings, but there were slightly significantly higher ratings of intensity by pain-intolerant participants. This could be construed to suggest that the salient feature associated with pain intolerance was sensory rather than affective.

Geisser et al. (1992) found that McGill Pain Questionnaire Present Pain Intensity scores of pain-intolerant participants were higher, in agreement with higher numerical pain ratings on a 0 (*no pain*) to 10 (*worst possible pain*) scale every 10 seconds throughout immersion. However, there were no differences in any other McGill Pain Questionnaire scores.

Lautenbacher et al. (1995) found that McGill Pain Questionnaire Affect, Miscellaneous, and Present Pain Intensity scores were higher for pain-intolerant participants, consistent with visual analog scale scores measured every 20 seconds for both intensity (*no pain - - extremely intense pain*) and unpleasantness (*no pain - -*

extremely unpleasant pain). However, there was no difference in McGill Pain Questionnaire Sensory scores, and in a reversal that the authors considered odd, the McGill Pain Questionnaire Evaluative scores were actually lower among pain-intolerant participants.

Hence there is a consensus among studies that pain ratings by pain-intolerant participants are higher than those of pain-tolerant participants. What is striking is the consistent lack of difference between groups in McGill Pain Questionnaire Sensory scores, and the lack of consistency in the Affect and especially Evaluative scores. The higher McGill Pain Questionnaire Affective scores reported by Chen et al. (1989b) and Lautenbacher et al. (1995)(but not Geisser et al., 1992), along with the affect visual analog scale data of Lautenbacher et al. (but not Chen et al., 1989b), provides tentative support for the hypothesis that there is a relatively increased affective response among pain-intolerant participants.

d) Traits

Bandura (1997) had reviewed studies which include demonstrations of a positive relationship between perceived self-efficacy and cold pressor pain tolerance. Litt (1988) found that enhanced self-efficacy and perceived control, both of which were experimentally manipulated in 102 female undergraduates, were positively correlated with cold pressor pain tolerance, and that state anxiety, as measured by the Profile of Mood States, had no effect.

Davidson and Bobey (1970) found in a sample of 72 female nursing students that repressors, as measured by the Repression-Sensitization Scale (Byrne, 1961) tolerated more cold pressor pain than sensitizers. In an earlier study, however, Davidson and McDougall (1969a,b) had found no effect of neuroticism, as measured by the Maudsley Personality Inventory, on cold pressor tolerance in two samples of female participants in Calgary.

Chen et al. (1989b) found no difference in State-Trait Anxiety Inventory state or trait anxiety between pain-tolerant and pain-intolerant groups. Nor did Geisser et al. (1992), but those authors did find that pain-tolerant participants scored lower on the catastrophizing subscale of the Coping Skills Questionnaire (Keefe et al., 1990). Geisser et al. also found that pain-tolerant participants demonstrated a higher pain report criterion, *B*, than pain-intolerant participants, on the Situational Pain Questionnaire, but did not find a difference in discriminability, as indexed by *P(A)*.

In the one study that demonstrated an effect of hardiness, Van Treuren and Hull (1987) found that commitment was associated with lower discomfort (not pain) ratings, but not tolerance time.

2) Summary of Findings

On balance, the available data suggest that pain-tolerant individuals do report less pain. Their numerical and visual analog ratings during pain induction have been shown to be lower, as have their questionnaire verbal ratings following induction. The questionnaire data suggest that the lesser reported pain is associated with diminished affect rather than sensory experience. It does not appear to be explained by less anxiety, but may reflect a generally elevated pain criterion. Data regarding group differences in positive affect do not appear to be available.

3) The Current Study

a) Rationale

In order to understand the meanings associated with the expected divergent cold pressor stimulus-response curves of pain-tolerant and pain-intolerant groups, graded verbal responses rather than numerical or visual analog quantities were measured. To better understand the expected difference in affective response, a broader range of emotional categories, including euthymic ones, were assessed. To evaluate whether pain tolerance was a stable trait, responses to multiple painful events were recorded. To elucidate the role of anxiety, if any, both cognitive and somatic anxiety were measured. Psychological hardiness was measured to determine whether pain tolerance was in part attributable to a greater predisposition to respond to pain adaptively. As an index of the intensity of maximum stimulation, thumb pad skin temperature at withdrawal was measured.

b) Hypotheses Tested

i) Thresholds and Stimulus-Response Functions

It was predicted that latencies to report painful verbal category responses by pain-tolerant participants would be significantly longer. Because findings regarding a difference in pain detection threshold have been equivocal, it was predicted that the longer latencies would be evident at a pain report level higher than the lowest category (since the lowest category would correspond to the pain detection threshold). There being no previous reports of measurements of sensations below the pain range, it was difficult to predict how the groups would differ. However, since McGill Pain Questionnaire Sensory scores did not differ between groups in prior studies, no differences in non-painful verbal category reports were predicted.

ii) Multidimensional Affect and Pain Survey

It was further predicted that pain-tolerant participants would have lower Emotional supercluster scores than pain-intolerant participants, but that Somatosensory supercluster scores would not differ between groups. On the basis of the self-efficacy manipulation study by Litt (1988), it was predicted that pain-intolerant participants would have higher Well-Being supercluster scores. Differential predictions regarding individual clusters were not made *a priori*. (No prediction was made regarding the Anxiety cluster since it represents cognitive rather than somatic anxiety).

iii) Traits

On the basis of the Situational Pain Questionnaire data reported by Geisser et al. (1992) that demonstrated a higher pain criterion among pain-tolerant participants, a similar prediction is made regarding the Experienced Pain Questionnaire data in this study, buttressing the inference that pain-tolerance generalizes outside the laboratory. On the basis of previous similar studies as well as the distinctions made by Cloninger (1986) and Schalling (1985), it was predicted that pain-tolerant participants would demonstrate lower somatic anxiety, but not cognitive anxiety. Finally, again on the basis of the self-efficacy manipulation study by Litt (1988), it was predicted that pain-tolerant participants would demonstrates greater psychological hardiness. Differential predictions regarding control, commitment, and challenge were not made *a priori*.

iv) Skin Temperature

It was predicted that thumb pad skin temperatures would be lower at withdrawal for pain-tolerant participants, indicating greater cold stimulation as a function of longer immersion times.

METHODS

Participants

104 normal healthy volunteers were recruited in response to posted notices and newspaper advertisements. There were 56 women and 48 men; 37 African-Americans, 35 Euro-Americans, and 32 of Puerto Rican descent. 90% were born on the U.S. mainland; all had been educated here. Participants had a mean age of 27.0 [SD 6.2] years and 15.3 [SD 2.0] years of education. 75% were unmarried; 20% were married; 5% were divorced. 49% were students; 36% were employed full-time, 9% part-time, and 6% were

unemployed. All participants reported being in good health, currently free of any painful conditions and drugs of abuse, and medication-free for at least 24 hours. Women participated during days 5 to 18 of their menstrual cycles to avoid potential physical discomfort and mood changes associated with the early follicular and later luteal phases.

One fact that bears mentioning is that the participants who participated in this study are the same as those who participated in the prior study of semantic judgments on which the Multidimensional Affect and Pain Survey is based.

Materials

The State Trait Anxiety Inventory (Spielberger et al., 1970) is a common method of measuring cognitive anxiety, and has been used extensively in pain studies. It includes 20 items measuring state and 20 items measuring trait anxiety. The Brief Symptom Inventory (Derogatis & Melisaratos, 1983), also used extensively in pain studies, is the abbreviated version of the Symptom Checklist-90-R, is a list of 53 self-statements that reflect 9 symptom dimensions, three of which are related to anxiety: Somatization, which serves as an index of somatic anxiety; Anxiety, which reflects cognitive anxiety; and Phobic

Anxiety, which is an index of agoraphobia. The three distinct anxiety measures confer an unusual specificity and capacity to identify anxiety subtypes. (The other six dimensions are Obsession-Compulsion, Interpersonal Sensitivity, Depression, Hostility, Paranoid Ideation, and Psychoticism. A score is calculated for each of the symptoms. There are also 3 summary indices: The General Severity Index, the Positive Symptom Distress Index, and the Positive Symptom Total. No predictions were made regarding those scores in the current study.)

The Personal Views Survey (Hardiness Institute, 1985) was designed by Maddi and Kobasa to assess the psychological hardiness construct. It yields subscales for Control, Commitment, and Challenge, and an overall Hardiness score.

The Experienced Pain Questionnaire, already described, appears in Appendix 2.

Procedure

All participants gave informed consent as stipulated and approved by the Institutional Review Board of the New York State Psychiatric Institute.

Prior to the laboratory pain induction, participants completed the State-Trait Anxiety Inventory, the Brief Symptom Inventory, the Personal Views Survey, and the

Experienced Pain Questionnaire.

Prior to immersion, ambient room temperature and baseline thumb pad skin temperature were recorded with a rigid shaft 10mm gold thermistor connected to a Physitemp Bat 8 thermometer. The cold pressor bath was prepared by half-filling an 18" X 12" X 12" styrofoam container with ice, and then with water to a height of 15". The mixture contained sufficient amounts of both phases to maintain the equilibrium temperature of .4°C.

Seated participants were instructed that when asked to begin, they were to immerse the hand of their choice up to the wrist with fingers outspread into the ice-water slurry for a maximum duration of three minutes. To avoid laminar warming, patients were advised to gently supinate and pronate their forearms. They were told that the maximum duration of the induction would be 3 minutes; that they did not have to persist for that entire time if they felt they could not, but they were asked to try. They were also told that they would be asked every 10 seconds for a sensation rating from the following scale:

12345678910

WARM	NOTHING	COOL	COLD	VERY COLD	FAINT PAIN	MODERATE PAIN	SEVERE PAIN

Participants were advised to use the numbers located over

SEVERE PAIN if they needed to make distinctions within that category, but the numbers were essentially ignored.

Upon immersion, a manual stopwatch was activated. Responses were recorded every 10 seconds until withdrawal, at which time withdrawal time and thumb pad skin temperature were recorded, the hand was quickly dried, and the participant was presented with the 189 descriptors of the Multidimensional Affect and Pain survey in random order on a microcomputer, on which the participant also entered their ratings on a 0 to 9 scale. Participants then completed their payment vouchers and left the laboratory.

Data Analysis

Dichotomy

In accord with the dichotimization of Chen et al. (1989b), participants who endured the full 3 minutes of cold pressor stimulation were categorized as pain-tolerant

Thresholds and Stimulus-Response Functions

To facilitate comparison of the data with those of other studies, the ranks of the words on the response scale were assigned, beginning with zero for NOTHING (WARM was never used), up to 6 for SEVERE PAIN and 7 for withdrawal. The means of those ranks (on the ordinate) were plotted against the 10-second increments (on the abscissa) at which participants were asked for cold pressor ratings.

However, these were not the data which were analyzed for several reasons. First, although the magnitudes assigned to words can approximate an interval level of measurement (Gracely et al., 1978a; Duncan et al., 1989), the response category descriptors used in this study were not selected on the basis of numerical equivalence. Hence the ranks assigned to those words *post hoc* are ordinal at best.

Secondly, although withdrawal may have been assigned the maximum value, withdrawal as a pain rating does not convey the same kind of information as do actual sensory ratings, which vary proportionally with sensory experience. Finally, confounding due to the ceiling effect created by a maximum assigned value is not evenly distributed in a cumulative stimulation protocol since the response range becomes more compressed with time.

Hence, a Greenhouse-Geisser-corrected repeated measures ANOVA was performed with group as the between factor and incremented latencies to reports of COLD, VERY COLD, FAINT PAIN, MODERATE PAIN, and SEVERE PAIN as the repeated measure. (Since raw latencies were cumulative, incremented latencies were analyzed to improve the independence of the repeated measures.) Reports of WARM, NOTHING, and COOL were rare and therefore excluded from the analysis.

For post-hoc pairwise comparisons, independent *t*-tests were performed and associated probabilities were adjusted for homogeneity of variance (Levene) and multiple comparisons. Rather than the extremely conservative Bonferroni method, which can produce a high number of type II errors, the "sharper Bonferroni method" of Hochberg and Benjamini (1990) was used to correct for multiple comparisons.

Independent *t*-tests were performed to compare pain range (duration between first report of pain and pain withdrawal) and severe pain range (duration between first report of SEVERE PAIN and withdrawal).

Multidimensional Affect and Pain Survey

First, sign tests were performed to compare numbers of higher cluster scores for pain-tolerant participants and pain-intolerant participants. Sign tests were also performed to compare numbers of higher individual word scores for the two groups.

Second, a Greenhouse-Geisser-corrected repeated measures ANOVA was performed with group as the between factor and SOMATOSENSORY, EMOTIONAL, and WELL-BEING supercluster mean ratings as the repeated measure.

Third, a finer-grained Greenhouse-Geisser-corrected repeated measures ANOVA was performed with group as the between factor and the 30 individual cluster mean ratings as the repeated measure.

For post-hoc pairwise comparisons, independent *t*-tests were performed and associated probabilities were adjusted for homogeneity of variance (Levene) and multiple comparisons (Hochberg and Benjamini, 1990).

Finally, for exploratory purposes, independent *t*-tests were performed on the mean ratings for the 189 individual words.

Traits

A Kolmogorov-Smirnov test was performed to test whether the response distributions on the Experienced Pain Questionnaire of pain-tolerant participants and pain-intolerant participants differed. The sensory decision theory parameters *P(A)* and *B* were calculated using a computer program implementing the published algorithm of McNicol (1972), and compared using independent *t*-tests.

Repeated measures ANOVA, followed when appropriate by post-hoc independent *t*-tests, corrected for multiple comparisons, were performed separately for the three sets of psychological measures: State and Trait Anxiety, the 9 individual scales of the Brief Symptom Inventory, and the

3 Hardiness scales. The three summary indices of the Brief Symptom Inventory were compared using independent t-tests. and those who withdrew sooner as pain-intolerant.

Skin Temperatures

Baseline and withdrawal skin temperatures were analyzed using repeated measures ANOVA.

RESULTS

Dichotomy

The full 3 minutes of cold pressor was endured by 31 pain-tolerant participants. The mean pain tolerance time of the pain-intolerant participants was 53 [SD 36] seconds, with a range of 10 to 162. Therefore, 72/73 pain-intolerant participants fell within 3 SDs from the mean (161 seconds), and all pain-tolerant participants fell outside 3 SDs.

Thresholds and Stimulus-Response Functions

Mean verbal response category ranks over time are depicted in Figure 4. Latencies to the five verbal pain report categories are depicted in Figure 5. Incremented latencies are depicted in Figure 6.

Repeated measures ANOVA of the incremented latencies indicated that there was a significant effect of pain

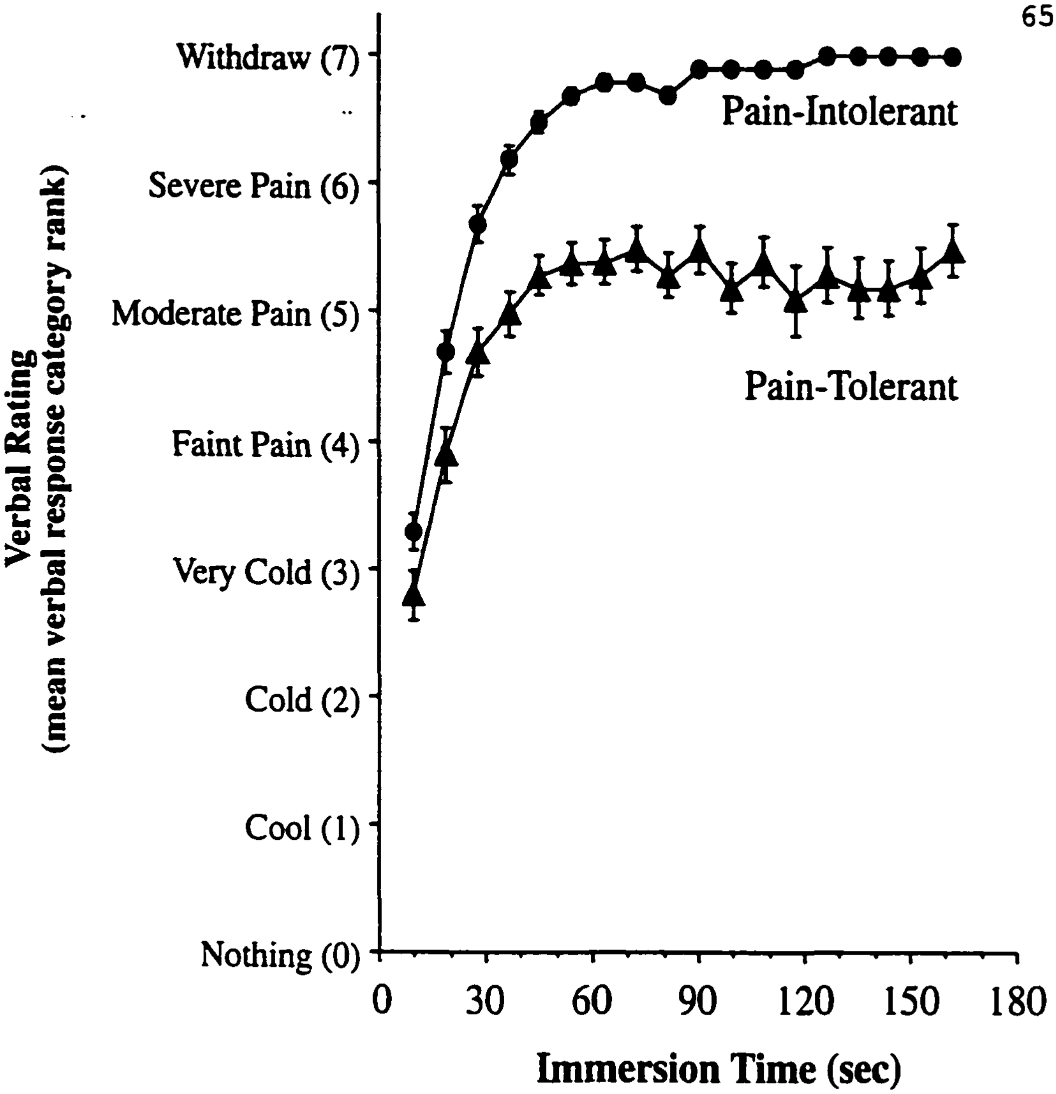


Figure 4. Mean ranks of ordered verbal responses made by pain-intolerant and pain-tolerant participants every 10 seconds in response to cold pressor stimulation. (The word WARM does not appear on the ordinate because it was not used.)

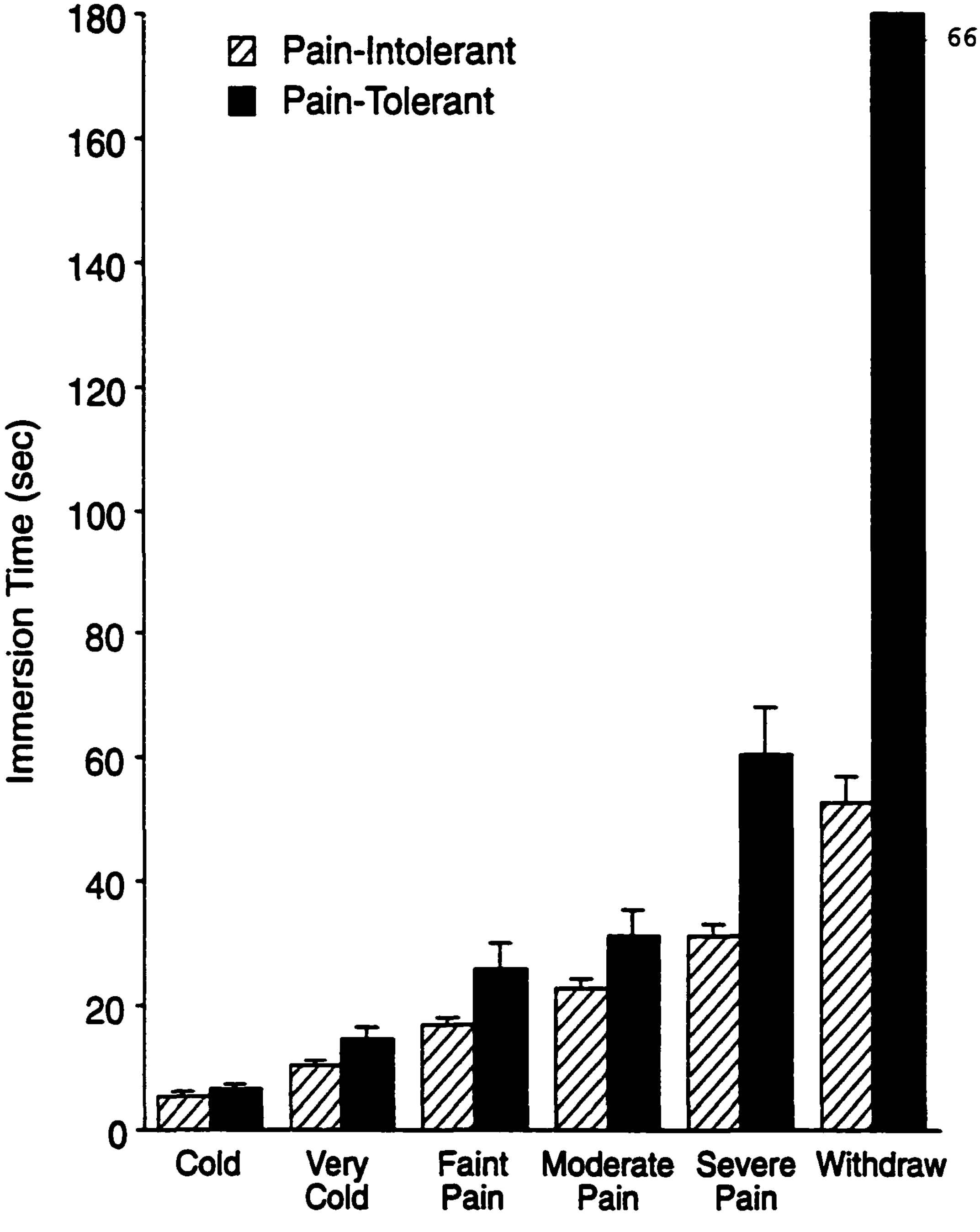


Figure 5. Mean *raw* latencies **(seconds elapsed from immersion onset)** to sensation category reports and withdrawal by pain-intolerant(n = 31) and pain-tolerant (n = 73) participants in response to cold pressor stimulation. Error bars represent standard errors. (There were insufficient data to analyze for the words WARM, NOTHING, and COOL.)

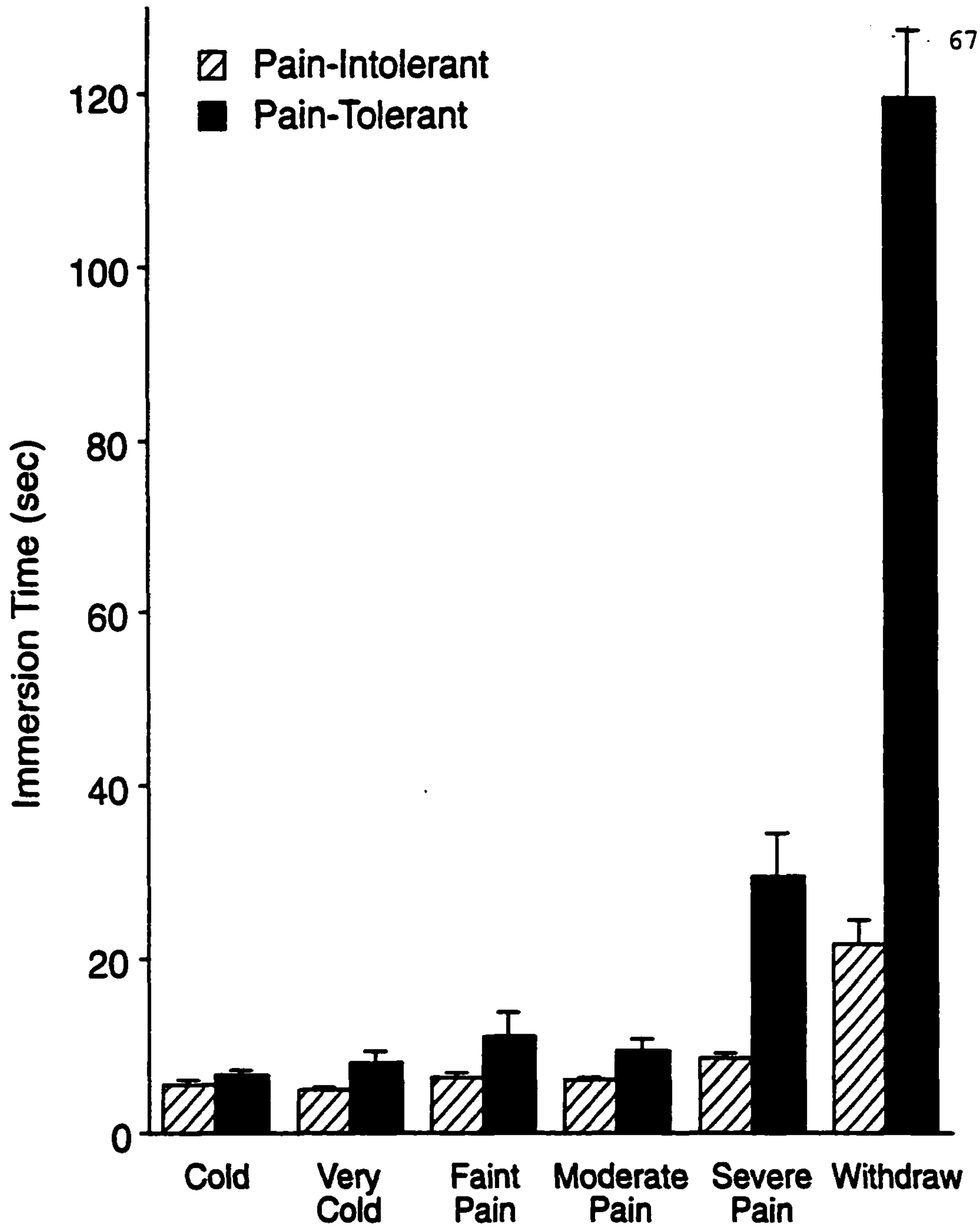


Figure 6. Mean *incremented* latencies **(seconds elapsed from report of immediately preceding sensation category *)** to sensation category reports and withdrawal by pain-tolerant (n = 31) and pain-intolerant(n = 73) participants in response to cold pressor stimulation. Error bars represent standard errors. (There were insufficient data to analyze for the words WARM, NOTHING, and COOL, hence latency to COLD is from immersion onset.)

report category ($F_{1.76,172.02}$ = 45.89, p<.001; η^2 = .32), a significant effect of group ($F_{1,98}$ = 27.86, p<.001; η^2 = .22), and a significant interaction ($F_{1.76,172.02}$ = 27.46, p<.001; η^2 = .22). Post-hoc pairwise independent *t*-tests of latencies to the 5 categories, controlled for homogeneity of variance (Levene) and multiple comparisons (Hochberg & Benjamini, 1990), indicated that pain-tolerant participants reported SEVERE PAIN ($t_{27.39}$ = 4.17, p<.001; η^2 = .30) significantly later, but not COLD (t_{102} = 1.38, p<.18; η^2 = .02), VERY COLD ($t_{35.35}$ = 2.01, p<.06; η^2 = .06), FAINT PAIN ($t_{27.39}$ = 1.68, p<.11; η^2 = .05), or MODERATE PAIN ($t_{35.40}$ = 2.52, p<.02; η^2 = .09).

T-tests comparing pain range and severe pain range indicated that pain-tolerant participants endured far more total pain (150 [SD 33] versus 36 [SD 32] sec; t_{102} = 16.45, p<.001, η^2 = .73) and more severe pain (119 [SD 40] versus 22 [SD 26] sec; $t_{34.28}$ = 11.72, p<.001, η^2 = .68) than intolerants. Twenty three of the 31 pain-tolerant participants reported SEVERE PAIN at withdrawal. Of the eight who did not, two had reduced their final report from SEVERE to MODERATE; two from SEVERE to FAINT. Only four never reported SEVERE PAIN. The maximum and final reports were MODERATE by one, and FAINT by another. The final report was COLD by the two others, whose maximum report had been FAINT.

In summary, the data indicate that the greater physical stimulation of the longer ice water immersion produced pain of greater duration, precluding the potential concern that numbness could have produced a qualitatively different pain experience among the pain-tolerant participants.

Multidimensional Affect and Pain Survey

Multidimensional Affect and Pain Survey cluster and supercluster data are presented in Table 1. Data for individual words are presented in Table 2.

Non-parametric analysis of frequencies of higher cluster mean scores using sign tests demonstrated that pain-tolerant participants scored higher ($p<.001$) on 15 out of 17 (88%) SENSORY clusters and also higher ($p<.001$) on 7 out of 8 (87%) SUFFERING clusters, but on only 2 out of 5 (40%) WELL-BEING ($p=1.0$).

The finer-grained non-parametric analysis (sign tests) of frequencies of higher individual word scores demonstrated lesser differences between groups: pain-tolerant participants scored higher ($p<.001$) on 69 out of 90 (77%) SENSORY words and also higher ($p<.001$) on 46 out of 58 (79%) SUFFERING descriptors, but on only 17 out of

Table 1. Mean [SD] ratings of cold pressor stimulation by pain-intolerant (n=73) and pain-tolerant (n=31) participants, for 30 Multidimensional Affect and Pain Survey (MAPS) clusters and 3 superclusters; η^2 associated with effect of group (* p<.05).

Cluster	Pain-Intolerant	Pain-Tolerant	η^2
1. Cutaneous	3.2 [1.6]	3.4 [1.3]	<.01
2. Temporal	2.6 [1.5]	2.7 [1.1]	<.01
3. Faint Pain	3.1 [1.6]	2.9 [1.3]	<.01
4. Muscle & Joint Pain	4.3 [1.8]	4.7 [1.9]	.01
5. Autonomic Distress	2.4 [2.0]	2.7 [2.2]	<.01
6. Mental Distress	5.6 [1.7]	5.8 [1.8]	<.01
7. Thermal	2.5 [1.7]	2.7 [1.6]	<.01
8. Pain Extent	4.8 [1.6]	5.3 [1.7]	.02
9. Intense Pain Qualities	5.3 [1.8]	5.7 [2.1]	.01
10. Intermittent Pressure	5.0 [2.4]	5.6 [2.1]	.02
11. Brightness	4.4 [1.8]	4.9 [1.6]	.02
12. Incisive Pressure	4.9 [1.8]	5.6 [1.8]	.03
13. Traction/Abrasion	3.8 [1.9]	4.0 [1.7]	<.01
14. Respiratory Distress	2.3 [1.9]	2.5 [1.9]	<.01
15. Cold	6.4 [2.0]	5.7 [1.9]	.03
16. Numb	5.5 [1.9]	5.9 [1.6]	.01
17. Pain Restriction	5.1 [2.1]	5.6 [1.9]	.01
I. Sensory Supercluster	**4.2 [1.2]**	**4.4 [1.1]**	**.01**

Cluster	**Pain-Intolerant**	**Pain-Tolerant**	η^2
18. Physical Ilness	3.8 [2.1]	4.4 [2.4]	.02
19. Depressed Mood	2.8 [1.4]	3.1 [1.5]	.01
20. Self-Blame	1.6 [1.2]	1.6 [1.0]	<.01
21. Anger	3.4 [1.8]	4.2 [2.2]	.04
22. Anxiety	4.1 [2.0]	4.6 [2.0]	.01
23. Fear	3.8 [2.0]	4.0 [1.7]	<.01
24. Mental Avoidance	1.7 [.87]	2.0 [.88]	.04 *
25. Physical Avoidance	1.8 [1.2]	2.1 [1.3]	.01
II. Suffering Supercluster	**2.9 [1.3]**	**3.2 [1.3]**	**.02**
26. Treatable Illness	3.2 [2.0]	3.6 [2.0]	.01
27. Mentally Healthy Activities	2.1 [1.4]	2.1 [1.0]	<.01
28. Physically Healthy Activities	3.8 [1.8]	3.7 [1.6]	<.01
29. Affiliative Feelings	1.4 [.68]	1.2 [.26]	.04 *
30. Positive Affect	1.4 [.49]	1.5 [.60]	.03
III. Well-Being Supercluster	**2.4 [.95]**	**2.4 [.77]**	**<.01**

Table 2. Mean [SD] ratings of individual Multidimensional Affect and Pain Survey (MAPS) descriptors by pain-intolerant and pain-tolerant participants; η^2 associated with effect of group (* $p<.05$).

	Pain-Intolerant	**Pain-Tolerant**	η^2
1. Itchy	2.0 [2.0]	1.9 [1.6]	<.01
2. Scratchy	1.7 [1.7]	2.0 [2.1]	<.01
3. Irritating Sensation	5.2 [2.9]	5.5 [2.4]	<.01
4. Crawling	3.1 [2.4]	3.0 [2.5]	<.01
5. Tickling	2.2 [2.0]	2.3 [1.7]	<.01
6. Tingling	5.0 [2.6]	5.7 [2.5]	.01
7. Flickering	2.5 [2.1]	2.5 [2.0]	<.01
8. Intermittent	1.8 [1.7]	2.5 [2.1]	.03
9. Brief	3.5 [2.8]	3.2 [2.1]	<.01
10. Dull Sensation	2.4 [2.2]	2.5 [2.1]	<.01
11. Vague Sensation	1.8 [1.5]	1.7 [1.2]	<.01
12. Mild Pain	4.4 [2.8]	4.0 [2.0]	.01
13. Superficial	2.5 [2.3]	2.3 [1.7]	<.01
14. Stiff	4.7 [3.0]	5.4 [2.8]	.01
15. Tight	4.1 [2.8]	5.1 [2.4]	.03
16. Aching	6.3 [2.7]	6.1 [2.8]	<.01
17. Sore Sensation	4.5 [2.9]	4.7 [3.0]	<.01
18. Tender Sensation	2.0 [2.0]	2.1 [1.9]	<.01
19. Disgusting	2.7 [2.4]	3.1 [2.8]	.01
20. Nauseating	2.2 [2.1]	2.3 [2.2]	<.01
21. Distressing	5.5 [2.7]	5.3 [2.7]	<.01
22. Disturbing	5.3 [2.8]	6.0 [2.4]	.02
23. Bothersome	5.9 [2.4]	5.7 [2.4]	<.01

	Pain-Intolerant	Pain-Tolerant	η^2
24. Troublesome	4.2 [2.6]	4.9 [2.5]	.02
25. Distracting	4.8 [2.9]	4.7 [3.1]	<.01
26. Uncomfortable	7.7 [1.7]	8.0 [1.6]	<.01
27. Burning	3.7 [2.9]	4.0 [2.9]	<.01
28. Scalding	2.1 [2.1]	2.4 [2.4]	<.01
29. Hot	1.5 [1.3]	1.6 [1.3]	<.01
30. Warm Sensation	1.2 [.72]	1.2 [.54]	<.01
31. Spreading	5.2 [3.0]	4.5 [3.1]	0.01
32. Worsening	7.0 [2.4]	6.6 [2.5]	<.01
33. Continuous	6.4 [2.4]	6.6 [2.2]	<.01
34. Persistent	6.1 [2.7]	6.7 [1.9]	.01
35. Lingering	5.7 [2.9]	5.7 [2.7]	<.01
36. Pervasive	4.6 [3.0]	4.7 [3.1]	<.01
37. Stubborn	2.6 [2.4]	4.1 [2.8]	.07*
38. Nagging	3.8 [2.7]	4.2 [2.6]	<.01
39. Intrusive	4.0 [2.8]	5.6 [2.8]	.06*
40. Cruel	4.4 [3.1]	5.2 [2.8]	.02
41. Vicious	4.4 [2.9]	5.4 [3.0]	.02
42. Nasty	4.5 [3.0]	5.5 [2.6]	.03
43. Fierce	6.2 [2.8]	6.7 [2.2]	.01
44. Killing	4.5 [2.9]	5.5 [3.0]	.03
45. Torturing	6.1 [2.9]	6.4 [2.8]	<.01
46. Excruciating	7.0 [2.3]	6.6 [2.6]	.01
47. Unbearable	7.4 [2.0]	6.4 [2.3]	.05*
48. Blinding	3.3 [2.6]	4.5 [2.8]	.04*
49. Overwhelming	6.4 [2.6]	6.0 [2.7]	<.01

	Pain-Intolerant	Pain-Tolerant	η^2
50. Horrible	5.5 [2.9]	5.6 [2.9]	<.01
51. Maddening	4.0 [2.9]	5.5 [3.0]	.05 *
52. Serious	4.9 [2.8]	4.9 [3.1]	<.01
53. Pulsing	4.8 [2.6]	5.7 [2.5]	.02
54. Throbbing	6.2 [2.8]	6.3 [2.4]	<.01
55. Pounding	3.9 [2.8]	4.7 [2.7]	.02
56. Pinching	3.7 [2.6]	4.1 [2.6]	<.01
57. Stinging	6.2 [2.5]	6.8 [2.3]	.01
58. Smarting	4.9 [2.7]	6.0 [2.5]	.04 *
59. Jumping	2.8 [2.4]	2.9 [2.6]	<.01
60. Biting	5.4 [3.0]	6.2 [2.6]	.02
61. Gnawing	3.8 [2.6]	4.6 [2.7]	.02
62. Deep	5.4 [2.7]	5.5 [2.6]	<.01
63. Penetrating	6.7 [2.3]	7.3 [2.2]	.01
64. Splitting	4.0 [2.7]	5.0 [2.9]	.03
65. Tearing	3.2 [2.5]	3.7 [2.5]	.01
66. Piercing	6.2 [2.6]	6.8 [2.3]	.02
67. Stabbing	4.5 [2.9]	6.0 [2.7]	.06 *
68. Cutting	4.1 [2.7]	4.8 [2.6]	.02
69. Sharp	5.7 [2.7]	6.6 [2.3]	.03
70. Shooting	5.1 [2.8]	5.1 [3.0]	<.01
71. Pulling	2.8 [2.4]	2.7 [2.1]	<.01
72. Tugging	2.8 [2.4]	2.9 [2.2]	<.01
73. Crushing	3.6 [2.6]	3.7 [2.6]	<.01
74. Grinding	2.8 [2.4]	3.2 [2.2]	<.01
75. Clenching	4.6 [2.7]	4.6 [2.9]	<.01

	Pain-Intolerant	Pain-Tolerant	η^2
76. Gripping	5.4 [2.6]	5.9 [2.1]	.01
77. Squeezing	3.5 [2.8]	4.1 [2.2]	.01
78. Pressing	3.7 [2.6]	3.9 [2.6]	<.01
79. Cramping	4.5 [2.9]	4.6 [2.8]	<.01
80. Choking	2.1 [2.1]	2.7 [2.4]	.02
81. Suffocating	2.6 [2.4]	2.8 [2.5]	<.01
82. Rasping	2.2 [2.2]	2.0 [1.9]	<.01
83. Cold Sensation	8.1 [1.5]	7.8 [1.9]	.01
84. Shivering	5.8 [2.8]	4.5 [2.7]	.04*
85. Cool Sensation	5.4 [3.0]	4.7 [2.7]	.01
86. Numb	6.5 [2.6]	7.0 [2.1]	.01
87. Numbing	7.3 [2.1]	7.5 [1.5]	<.01
88. Insensible	2.7 [2.2]	3.3 [2.4]	.02
89. Localized	6.0 [2.6]	6.6 [2.5]	.01
90. Restricted	4.2 [2.8]	4.5 [2.3]	<.01
91. Afflicted	3.8 [2.8]	3.8 [2.7]	<.01
92. Ailing	3.5 [3.0]	3.8 [3.0]	<.01
93. Suffering	5.4 [2.6]	6.2 [2.7]	.02
94. Destroyed	2.1 [2.0]	3.4 [2.8]	.07*
95. Incapacitated	4.0 [3.0]	4.9 [3.0]	.02
96. Lousy	4.7 [3.0]	4.6 [3.0]	<.01
97. Miserable	4.7 [2.9]	5.4 [3.0]	.01
98. Bad	5.6 [2.7]	6.1 [2.9]	.01
99. Lonely	1.5 [1.3]	1.9 [1.7]	.02
100. Rejected	1.7 [1.5]	1.0 [.00]	.06*
101. Depressed	1.7 [1.5]	2.0 [2.2]	.01

	Pain-Intolerant	Pain-Tolerant	η^2
102. Sad	2.0 [1.9]	2.1 [2.1]	<.01
103. Discouraged	2.6 [2.3]	2.6 [2.4]	<.01
104. Hopeless	2.1 [2.0]	2.7 [2.4]	.01
105. Sullen	1.5 [1.1]	1.9 [1.7]	.02
106. Unfortunate	2.7 [2.4]	3.5 [2.9]	.02
107. Grim	3.2 [2.6]	3.7 [2.8]	.01
108. Guilty	1.5 [1.5]	1.6 [1.7]	<.01
109. Negligent	1.6 [1.4]	1.5 [1.2]	<.01
110. Angry	2.5 [2.2]	3.6 [3.2]	.04
111. Furious	3.2 [2.7]	4.3 [3.0]	.04 *
112. Outraged	2.7 [2.4]	3.3 [3.0]	.01
113. Hostile	2.9 [2.3]	3.6 [2.9]	.02
114. Resentful	2.2 [2.0]	3.5 [3.0]	.06 *
115. Annoyed	3.7 [2.8]	4.2 [2.9]	.01
116. Displeased	4.7 [2.9]	5.3 [2.9]	.01
117. Upset	3.1 [2.6]	3.9 [3.1]	.02
118. Disagreeable	5.7 [2.8]	5.6 [3.2]	<.01
119. Aggressive	3.2 [2.7]	4.2 [2.6]	.03
120. Stressed	4.4 [2.8]	4.5 [2.8]	<.01
121. Tense	5.1 [2.7]	5.5 [2.6]	<.01
122. Anxious	4.8 [2.7]	5.5 [2.7]	.01
123. Agitated	4.5 [2.6]	4.8 [2.9]	<.01
124. Restless	3.3 [2.8]	4.1 [2.9]	.02
125. Harassed	2.3 [2.1]	3.0 [2.4]	.02
126. Alarming	5.3 [2.6]	5.7 [2.4]	.01
127. Startling	5.2 [2.9]	5.7 [2.6]	.01

	Pain-Intolerant	Pain-Tolerant	η^2
128. Frantic	4.5 [2.8]	4.2 [2.6]	<.01
129. Panic Stricken	4.0 [3.1]	3.9 [2.7]	<.01
130. Afraid	3.1 [2.5]	3.4 [2.5]	<.01
131. Terrified	3.0 [2.7]	3.3 [2.6]	<.01
132. Frightening	3.6 [2.7]	4.5 [2.9]	.02
133. Cowardly	2.6 [2.4]	2.0 [1.7]	.02
134. Desperate	3.9 [2.8]	4.5 [2.8]	.01
135. Shaky	3.8 [2.8]	4.4 [2.8]	.01
136. Cautious	2.5 [2.3]	1.8 [1.4]	.03
137. Apathetic	1.6 [1.4]	1.2 [.76]	.02
138. Indifferent	1.9 [2.0]	2.4 [2.2]	.01
139. Aloof	1.4 [1.3]	1.4 [.95]	<.01
140. Bored	1.2 [.68]	1.3 [.68]	<.01
141. Passive	1.5 [1.4]	1.9 [1.7]	.02
142. Stoical	2.3 [1.9]	4.0 [2.8]	.11*
143. Exhausting	2.5 [2.1]	2.7 [2.3]	<.01
144. Tiring	2.1 [1.8]	2.6 [2.2]	.01
145. Sleepy	1.2 [1.1]	1.3 [1.4]	<.01
146. Sluggish	1.7 [1.8]	2.3 [2.0]	.02
147. Dreamy	1.3 [1.3]	1.4 [1.1]	<.01
148. Lightheaded	2.0 [2.1]	2.5 [2.4]	.01
149. Curable	3.8 [3.3]	3.0 [2.4]	.02
150. Manageable	2.6 [1.7]	4.1 [2.2]	.13*
151. Healthy	1.8 [1.8]	1.5 [1.3]	.01
152. Pain-Free	1.2 [.96]	1.5 [1.2]	.02
153. Interested	2.3 [2.2]	2.2 [1.9]	<.01

	Pain-Intolerant	Pain-Tolerant	η^2
154. Involved	3.2 [2.9]	3.2 [2.3]	<.01
155. Active	3.3 [2.6]	2.8 [2.3]	.01
156. Energetic	2.8 [2.6]	2.4 [2.1]	.01
157. Alive	3.6 [2.8]	3.3 [2.6]	<.01
158. Adventurous	3.0 [2.5]	2.9 [2.4]	<.01
159. Vigorous	4.1 [2.9]	4.5 [2.9]	<.01
160. Alert	5.2 [3.0]	4.5 [2.8]	.01
161. Strong	5.2 [3.0]	6.4 [2.7]	.03
162. Arousing	3.5 [3.0]	3.3 [2.6]	<.01
163. Loved	1.2 [.65]	1.1 [.25]	.01
164. Needed	1.3 [.96]	1.2 [.45]	<.01
165. Affectionate	1.2 [.70]	1.0 [.18]	.01
166. Forgiving	1.9 [2.1]	1.4 [.98]	.02
167. Sympathetic	1.5 [1.7]	1.1 [.34]	.02
168. Agreeable	1.3 [.81]	1.2 [.37]	.01
169. Friendly	1.5 [1.1]	1.1 [.43]	.02 *
170. Hopeful	1.7 [1.6]	2.2 [1.9]	.02
171. Optimistic	1.9 [1.9]	1.9 [1.4]	<.01
172. Encouraged	1.3 [1.1]	1.9 [1.7]	.03
173. Lucky	1.1 [.49]	1.2 [.60]	.01
174. Cheerful	1.2 [.49]	1.5 [1.1]	.05
175. Happy	1.3 [1.2]	1.4 [.96]	<.01
176. Pleased	1.2 [.64]	1.4 [1.3]	.01
177. Satisfied	1.2 [.85]	1.4 [.91]	.01
178. Contented	1.3 [.87]	1.1 [.34]	.02
179. Fine	1.3 [.81]	1.5 [1.1]	.01

	Pain-Intolerant	Pain-Tolerant	η^2
180. Secure	1.5 [1.3]	1.8 [1.4]	.02
181. Calm	1.7 [1.5]	2.5 [2.2]	.05
182. Relaxed	1.4 [1.0]	1.4 [1.3]	<.01
183. Peaceful	1.1 [.56]	1.5 [1.3]	.03
184. Soothed	1.2 [.64]	1.1 [.25]	.01
185. Soothing	1.3 [1.1]	1.2 [.48]	<.01
186. Gentle	1.3 [.78]	1.2 [.76]	<.01
187. Pleasant	1.2 [.82]	1.1 [.25]	.01
188. Easing	1.2 [.96]	2.0 [1.8]	.08 *
189. Stroking	1.6 [1.5]	1.4 [.84]	.01

41 (41%) WELL-BEING clusters (p<.35).

Repeated measures ANOVA indicated that while supercluster mean scores differed significantly ($F_{1.51,\ 153.80}$ = 134.12, p<.001; η^2 = .57), there was no difference between groups ($F_{1,102}$ = 1.25, p<.27; η^2 = .01) and no interaction ($F_{1.51,\ 153.80}$ = 1.21, p<.30; η^2 = .01).

Repeated measures ANOVA similarly indicated that while cluster mean scores differed significantly ($F_{9.31,\ 949.47}$ = 94.70, p<.001; η^2 = .48), there was again no difference between groups ($F_{1,102}$ = 1.33, p<.26; η^2 = .01) and no interaction ($F_{9.31,\ 949.47}$ = 1.15, p<.33; η^2 = .01).

Hence, non-parametric analyses demonstrate greater endorsement by pain-tolerant participants of both sensory and suffering descriptors, with no difference in the endorsement of well-being descriptors. The lack of significance demonstrated by the parametric analyses is understandable in light of the extremely small effect sizes. (Tables 1 and 2.)

Traits

A Kolmogorov-Smirnov test of the frequency distributions of the Experienced Pain Questionnaire category responses (NONE/MILD/MODERATE/SEVERE) indicated no significant difference (Z =.998, p<.28) between pain-tolerant participants (44/452/365/173) and pain-intolerant participants (39/978/884/465).

There were no differences between pain-tolerant participants and pain-intolerant participants for *P(A)* (.69 [SD .10] versus .67 [SD .087]; t_{102} = 1.04, $p<.30$, η^2 = .01) or *B* (2.0 [SD .27] versus 1.9 [SD .19]; t_{102} = 1.12, $p<.27$, η^2 = .01).

Hence, the standard non-parametric analysis suggests that pain-tolerant participants and pain-intolerant participants do not differ in their experiences of pain outside the laboratory. The Sensory Decision Theory analysis further demonstrates that the two groups differ in neither their sensory acuity nor their response bias.

Data for the State-Trait Anxiety Inventory, Brief Symptom Inventory, and Personal Views Survey are presented in Table 3.

Repeated measures ANOVA of State and Trait Anxiety scores indicated that while Trait scores were significantly higher than State scores ($F_{1.76,172.02}$ = 45.89, $p<.001$; η^2 = .32), there was no effect of group ($F_{1,98}$ = 1.32, $p<.26$; η^2 = .01) and no significant interaction ($F_{1.76,172.02}$ = 0.23, $p<.63$; η^2 < .01).

There were no differences between groups for the

Table 3. Means [SD] scores of pain-intolerant and pain-tolerant participants for the State-Trait Anxiety Inventory (STAI), Brief Symptom Inventory (BSI), and Personal Views Survey (PVS); η^2 associated with effect of group. No differences were statistically significant at $p<.05$.

Measure	Pain-Intolerant	Pain-Tolerant	η^2
STAI:			
State Anxiety	47.6 [9.0]	49.7 [10.7]	.01
Trait Anxiety	52.9 [11.6]	55.8 [14.5]	.01
BSI:			
Somatization	.45 [.50]	.41 [.49]	<.01
Obsessive Compulsive	.88 [.69]	1.1 [.78]	.02
Interpersonal Sensitivity	.64 [.80]	.86 [.76]	.02
Depression	.57 [.63]	.85 [.78]	.04
Anxiety	.67 [.70]	.64 [.81]	<.01
Hostility	.71 [.62]	.83 [.61]	.01
Phobic Anxiety	.31 [.47]	.26 [.46]	<.01
Paranoid Ideation	.72 [.67]	.86 [.83]	.01
Psychoticism	.47 [.60]	.59 [.70]	.01
General Severity	.61 [.51]	.71 [.56]	.01
Positive Symptom Total	20.3 [13.7]	23.2 [12.4]	.01
Positive Symptom Distress	1.4 [.39]	1.5 [.46]	<.01
PVS:			
Control	.68 [.11]	.71 [.01]	.01
Committment	.82 [.01]	.78 [.13]	.04
Challenge	.77 [.01]	.76 [.13]	<.01
Hardiness	76.1 [7.3]	75.1 [10.5]	<.01

Brief Symptom Inventory General Severity Index (t_{99} = .84, p<.41, η^2 = .01), Positive Symptom Distress Index or (t_{99} = .07, p<.95, η^2 < .01), or Positive Symptom Total (t_{99} = 1.00, p<.32, η^2 = .01)

Repeated measures ANOVA of Brief Symptom Inventory symptom scales indicated that while there were significant differences among scale scores, ($F_{6.38,631.35}$ = 22.63, p<.001; η^2 = .19), there was no significant effect of group ($F_{1,99}$ = .95, p<.34; η^2 = .01), nor a significant interaction ($F_{6.38,631.35}$ = 1.94, p<.07; η^2 < .02).

Repeated measures ANOVA of Hardiness scores indicated that there were significant differences among scores, ($F_{1.80,\ 179.78}$ = 49.39, p<.001; η^2 = .33), but no significant effect of group ($F_{1,100}$ = .31, p<.58; η^2 < .01). There was a significant interaction ($F_{6.38,631.35}$ = 5.18, p<.01; η^2 = .05) such that pain-tolerant participants scored higher on CONTROL while lower on COMMITMENT and CHALLENGE, but post-hoc pairwise comparisons did not demonstrate any significant differences between groups.

Hence, the two groups do not differ overall in the traits measured, including any form of anxiety. Speculation that CONTROL contributes to pain tolerance must be guarded, in light of the lack of a significant main effect, and the lack of a compelling explanation why COMMITMENT and CHALLENGE was higher among pain-intolerant participants.

Skin Temperatures

Repeated measures ANOVA of the baseline and withdrawal temperatures indicated that there was a significant effect of immersion ($F_{1,102} = 2391.71$, $p<.001$; $\eta^2 = .96$), a significant effect of group ($F_{1,102} = 66.38$, $p<.001$; $\eta^2 = .39$), and a significant interaction ($F_{1,102} = 79.48$, $p<.001$; $\eta^2 = .49$). While the mean baseline skin temperature of pain-tolerant participants was only 1.1 degrees cooler (31.3 [SD 3.2]°C versus 30.2 [SD 3.3]°C; $t_{102} = 1.62$, $p<.11$; $\eta^2 = .02$) than that of pain-intolerant participants, the mean decrease in temperature at withdrawal among pain-tolerant participants was approximately one and a half times that among pain-intolerant participants (14.8 [SD 3.8]°C versus 6.3 [SD 2.4]°C; $t_{102} = 13.65$, $p<.001$; $\eta^2 = .56$), demonstrating that cold stimulation was more intense for pain-tolerant participants than for pain-intolerant participants.

DISCUSSION

Skin Temperatures, Thresholds, and Stimulus-Response Functions

The results confirm the hypotheses that the longer physical stimulation endured by pain-tolerant participants would be reflected by lower skin temperatures at withdrawal, and that pain-tolerant participants would demonstrate longer latencies to report levels of pain only above the pain threshold. The latency at which the groups differed corresponded to the level of SEVERE PAIN.

These results contrast with those of previous studies that used non-verbal response measures which showed a more consistent elevation of pain-tolerant responses relative to pain-intolerant participants. Some might consider this grounds for criticism of verbal scales as being less sensitive at lower stimulation intensities. However, the conclusion ventured here is that when attention is focused on non-painful sensation apart from pain, verbal response data are actually more meaningful (such as whether one's pain is what one would call *severe*) than simple numerical ratings of general intensity.

Is it possible that pain-tolerant participants felt diminished painful stimulation only at colder temperatures? To account for the much smaller differences between groups at the two non-painful levels and the two lesser pain levels, one could speculate that some neurophysiological threshold, once exceeded, could attenuate sensation and render it more bearable. This is not a parsimonious explanation, but plausible in that extreme cold produces numbness and perhaps pain-tolerant participants had a lower numbness threshold. This speculation is not supported by the data, however, since once severe pain was reported, it continued to be reported until withdrawal in the majority of cases.

The conclusion ventured here is that there is not a difference at the level of sensory perception, or, more literally, sensation, but rather in evaluation, such that pain-tolerant participants do not have an elevated pain threshold, but an elevated "severity threshold" (Ellington & Wiebe, 1999), consistent with a stoical response style. What might account for this finding? First, being the ultimate category on the scale, it was not only the worst that sustained pain could possibly be, it also represented the closest one could come to quitting. It was known *a priori* that the two groups would differ on the key variable of behavioral persistence. Perhaps this verbal difference is simply a consistent manifestation of resistance to quitting. Alternatively, although *severe* is included quite commonly in verbal pain scales, there is a potentially horrific and overwhelming quality to "severe" that may have resonated less with pain-tolerant participants.

These preceding points should not be understood to suggest that *severe* means different things to pain-tolerant participants and pain-intolerant participants. Gracely et al. (1978a,b) demonstrated convincingly that words are reliably scaled among individuals. The interpretation ventured here is that pain-intolerant participants found cold pressor stimulation more severe and quit sooner therefore.

Similar attention to semantics may serve to explain the potentially puzzling data reported by Chen et al. (1989b), who found that cold pressor "intensity" ratings were higher among pain-intolerant participants, while "unpleasantness" ratings, the presumed measure of pain affect, did not differ. Inspection of the anchors of the visual analog scales used in that study clarifies the matter. The high end of what was presumed to be the "affect" scale was labeled *as unpleasant as possible*, whereas the high end of what was presumed to be the "intensity" scale was labeled *as bad as possible*. Like the term *severe, bad* is multidimensional and perhaps better represented the extreme unpleasantness of cold pressor pain experience than did *unpleasant*. If so, then the data in this study may actually concur with those of Chen et al.

Multidimensional Affect and Pain Survey

Although the differences between both cluster mean scores and individual word scores were admittedly small, non-parametric analyses of both indicated significant differences in the direction *opposite* to that predicted: scores of pain-tolerant participants were generally higher, not lower, than those of pain-intolerant participants. Furthermore, there was a striking similarity between the proportions of higher Somatosensory and Emotional ratings by pain-tolerant participants, for both cluster means and descriptors.

It is entirely reasonable for pain-tolerant participants to have produced higher scores because they endured both more cold stimulation and more pain than pain-intolerant participants. What, then, can account for the stark disparity between these findings and the preponderance of previous findings that demonstrated *lower* scores produced by pain-tolerant participants?

The most likely explanation lies in differences in construction and administration of the McGill Pain Questionnaire and the Multidimensional Affect and Pain Survey. The Multidimensional Affect and Pain Survey includes a considerably greater number of items to measure a wider range of affective responses to pain. Furthermore, responding to the McGill Pain Questionnaire entails checking a single item per group which is pre-assigned a rank; McGill Pain Questionnaire scores are sums of those ranks. Responding to the Multidimensional Affect and Pain Survey entails assigning a numerical rating to each and every word; Multidimensional Affect and Pain Survey cluster scores are means of those ratings.

The more informative response profile resulting from the more comprehensive assessment by the Multidimensional Affect and Pain is apparent from the results of this study. When pain-tolerant participants are given the opportunity to thoroughly and completely describe their pain experience, they account for more pain and its associated affective and cognitive effects, not less. Furthermore, the profile did not support the hypothesis that pain-tolerant participants experience comparable sensory stimulation but attenuated distress. The relatively greater endorsement of both dimensions, although small, was comparable for both sensory and affective domains. Finally, any hypothesized compensatory euthymic effect in the face of negative experience found no support by these data.

Is it possible that the choice to endure pain has nothing to do with how it feels? Could it be alone attributable to individual differences?

Traits

It was hypothesized that pain-tolerant participants would evidence less somatic anxiety. However, on every one of the 3 of 9 Brief Symptom Inventory scales that measure some parameter of anxiety (Somatic Anxiety, Anxiety, and Phobic Anxiety), there was no difference between groups. Similarly, scores on both State and Trait Anxiety failed to demonstrate a difference between groups. Hence, the findings do not support the hypothesis that anxiety affects cold pressor pain tolerance.

The hypothesized effect of psychological hardiness was also unconfirmed, in accord with the finding of no difference between groups in Well-Being scores on the Multidimensional Affect and Pain Survey. Finally, the Sensory Decision Theory data analysis of Experienced Pain Questionnaire data provided no support whatsoever for a hypothesized stable diminution among pain-tolerant participants of either pain sensation or pain report.

Exploratory Data Analyses

Although there were no significant differences between pain-tolerant participants and pain-intolerant participants as indexed by Well-Being cluster scores, the greatest and second-greatest amount of pain tolerance variance accounted for by any of the 189 individual Multidimensional Affect and Pain Survey words were *manageable* (13%) and, not surprisingly, *stoical* (11%).

There is something of an inconsistency with regard to the word *stoical*. Stoicism is often considered as an explanation for diminished pain responsiveness, but the essence of Stoicism is minimization of emotion. Applying the philosophy to pain dictates that although physical sensations must be acknowledged since they are real, they are nonetheless to be regarded objectively and dispassionately. Therefore, one would not expect a stoic to be necessarily insensitive to pain, merely not to be distressed by it. If attenuated distress diminishes overall pain experience, then stoical individuals could be reasonably to demonstrate greater behavioral pain tolerance, but only in conjunction with a penchant for emotional understatement, which these data do not support.

In an attempt to answer the question, "Are runners stoical?", Janal et al. (1994) compared pain responsiveness in regular runners to that of normal controls. Some of their data suggested diminished pain responsiveness by runners, who reported lower levels of pain at longer latencies, but not higher levels overall. The conclusion was that runners were not more stoical than controls. In a later paper, Janal (1996) made the distinction between stoicism and persistence, explaining that one could tolerate more pain without any diminished responsiveness.

The notion of diminished responsiveness is consistent with the findings of Litt (1988), whose high self-efficacy participants, who demonstrated greater pain tolerance, reported higher levels of pain sensation and affect, much as the pain-tolerant participants in this study did. He suggested that self-efficacy was oriented toward performance, not perception, and there was not necessarily a reason to expect that pain-tolerant participants feel less pain or expect to. Similarly, Tajet-Foxell and Rose (1995) found that ballet dancers, who demonstrated higher cold pressor pain thresholds and higher cold pressor pain tolerance than controls, also produced higher McGill Pain Questionnaire Sensory ratings, higher McGill Pain Questionnaire Affect ratings, and even higher neuroticism scores. As Schermelleh-Engel et al. (1997) noted, perceived competence can trump anxiety. This was likely true for the participants in this study, for whom the most salient individual Multidimensional Affect and Pain Survey word was *manageable*, and the most salient word overall was *severe*.

These findings strongly suggest the relevance of stress-resistance variables, and make the absence of significant differences in psychological hardiness all the more curious. Pain tolerance is evidently not due to diminished stimulation, sensation or differences in pain-related affect, either positive or negative. It represents a choice to persist in the face of pain, even severe pain, despite discomfort and unpleasantness, and it is a behavior which remains to be explained.

Future Research

Choices to tolerate pain (and its diminutive twin, discomfort) are typically made because of some instrumental value. Future studies should therefore include protocols wherein pain must be endured in order to attain some other objective, or receive some reinforcement, allowing for an assessment of the relative saliencies attributed to both the painful and reinforcing stimuli. A means of assessing the trait of persistence may also serve to explain more of the variance in pain tolerance than has been thus far accomplished.

Cloninger's (1986) tridimensional, now tetradimensional (Cloninger et al., 1993) model, including the dimensions of novelty-seeking, harm avoidance, reward dependence, and persistence, would provide an excellent means of studying pain tolerance. One would expect that pain-tolerant individuals would be characterized by higher Tridimensional Personality Questionnaire (Cloninger et al., 1991) scores for novelty-seeking and persistence, and lower on harm avoidance. The reward dependence dimension would also contribute important information, in conjunction with a measure of the *value* that the participant placed on success at the tolerance task, a key unexplored variable.

The value accorded success in the task could be assessed using a situationally specific measure of the expectation of success, to assess perceived self-efficacy, as well as a measure of dispositional need for achievement. To control for the demand characteristics (Orne, 1962) associated with performance in the laboratory, a similar situationally specific measure of the desire to comply fully with directions could be accompanied by an assessment of social desirability. Such a comprehensive set of variables would constitute a potentially powerful method of improving our understanding of what accounts for pain tolerance.

Finally, one of the limitations of cumulative stimulation paradigms such as the cold pressor test is the relatively limited ability to discern between pain sensation and pain report. Responses to multiple presentations of a set of calibrated stimulus intensities, on the other hand, can be analyzed using Sensory Decision Theory methods. If data were gathered in a protocol which included ice-water immersions of variable defined lengths, one could better test the hypothesis that pain-tolerant participants and pain-intolerant participants did not differ in sensory sensitivity, indexed by *P(A)*, but rather in their criterion, *B*, for reporting pain.

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Appendix 1
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Appendix 2 (2 pages)

The Experienced Pain Questionnaire (Clark, unpublished)

PAIN EXPERIENCES

______________________________ ________

NAME DATE

Listed below are some situations which cause pain or discomfort. For each, indicate your experience with a situation by circling the appropriate word. If you have experienced a situation, then indicate whether your *worst* such experiences was mildly, moderately, or severely discomforting.

SITUATION	DEGREE OF DISCOMFORT				
	Never	None	Mild	Moderate	Severe
Toothache	____	____	____	____	____
Earache	____	____	____	____	____
Muscle cramp	____	____	____	____	____
Labor pain	____	____	____	____	____
Paper cut	____	____	____	____	____
Headache (Specify:)	____	____	____	____	____
Nausea	____	____	____	____	____
Drill tooth w/o anesthesia	____	____	____	____	____
Hit "funny bone"	____	____	____	____	____
Muscle soreness	____	____	____	____	____
Sprain (ankle, wrist, knee)	____	____	____	____	____
Stub toe	____	____	____	____	____
Heartburn or Indigestion	____	____	____	____	____
Injection or blood test	____	____	____	____	____
Bang shin	____	____	____	____	____
Foreign body in eye	____	____	____	____	____
Gall or kidney stones	____	____	____	____	____
Sunburn	____	____	____	____	____
Heart attack	____	____	____	____	____

SITUATION	DEGREE OF DISCOMFORT				
	Never	None	Mild	Moderate	Severe
Bitter cold weather	____	____	____	____	____
Scald self as w/ boiling water	____	____	____	____	____
Scrape skin as in fall	____	____	____	____	____
Splinter in finger	____	____	____	____	____
Skin boil or abscess	____	____	____	____	____
Tear a ligament	____	____	____	____	____
Pinch skin (zipper, pliers)	____	____	____	____	____
Crush injury (specify:)	____	____	____	____	____
Hot, humid weather	____	____	____	____	____
Hit w/ blunt object	____	____	____	____	____
Catch finger in door	____	____	____	____	____
Fracture a bone	____	____	____	____	____
Appendicitis	____	____	____	____	____
Cut self as w/ knife	____	____	____	____	____
Stitches w/o anesthesia	____	____	____	____	____
Hit finger with hammer	____	____	____	____	____
Bruise (specify:)	____	____	____	____	____
Backache	____	____	____	____	____
Abdominal cramps	____	____	____	____	____
Cut self shaving	____	____	____	____	____
Salt or iodine in cut	____	____	____	____	____
Hemorrhoidal surgery	____	____	____	____	____
Sore throat	____	____	____	____	____
Mosquito bite itch	____	____	____	____	____
Bee sting	____	____	____	____	____
Burn (specify:)	____	____	____	____	____
After a tooth extraction	____	____	____	____	____
Menstrual pain	____	____	____	____	____
Other (specify:)	____	____	____	____	____

REFERENCES

Allred, K.D., & Smith, T.W. (1989). The hardy personality: Cognitive and physiological responses to evaluative threat. *Journal of Personality and Social Psychology, 56,* 257-266.

American Pain Foundation (2000, Fall). *Stop pain now! APF gets ready for launch of agressive four-part campaign to make pain a national healthcare priority.* Baltimore: Author.

American Pain Society Quality of Care Committee. (1995). Quality improvement guidelines for the treatment of acute pain and cancer pain. *The Journal of the American Medical Association, 274,* 1874-1880.

Bandura, A. (1997). Self-efficacy: The exercise of control. New York: W.H. Freeman.

Beecher, H.K. (1959). *Measurement of subjective responses.* New York: Oxford.

Berkley, K. (1997). Sex differences in pain. *Behavioral and Brain Sciences, 20,* 371-80.

Bobey, M.J., & Davidson, P.O. (1970). Psychological factors affecting pain tolerance. *Journal of Psychosomatic Research, 14,* 371-376.

Boothby, J.L., Thorn, B.E., Stroud, M.W., & Jensen, M.P. (1999). Coping with pain. In R.J. Gatchel & D.C. Turk (Eds.), *Psychosocial factors in pain: Critical perspectives* (pp. 343-359). New York: Guilford.

Brame, G. (2000). *Different loving: The world of sexual dominance and submission.* New York: Random House.

Brattberg, G., Thorslund, M., & Wikman, A. (1988). The use of common pain experiences in designing a pain intensity scale for epidemiological purposes. *Journal of Psychosomatic Research, 32,* 505-512.

Buss, A.H., & Portnoy, N.W. (1967). Pain tolerance and group identification. *Journal of Personality and Social Psychology, 6,* 106-108.

Byrne, D. (1961). The repression-sensitization scale: Rationale, reliability, and validity. *Journal of Personality, 29,* 334-339.

Carroll, J.D., & Chang, J.J. (1970). Analysis of individual differences in multidimensional scaling via an N-way generalization of 'Eckart-Young' decomposition. *Psychometrika, 35,* 283-319.

Casey, K.L., & Bushnell, M.C. (2000). *Pain imaging.* Seattle: IASP Press.

Chapman, C.R. (1983). On the relationship of human laboratory and clinical pain research. In R. Melzack (Ed.), *Pain measurement and assessment* (pp. 243-250). New York: Raven.

Chapman, C.R., Casey, K.L., Dubner, R., Foley, K.M., Gracely, R.H., & Reading, A.E. (1985). Pain measurement: an overview. *Pain, 22,* 1-31.

Chen, A.C.N., Dworkin, S.F., Haug, J., & Gehrig, J. (1989a). Topographic brain measures of human pain and pain responsivity. *Pain, 37,* 143-160.

Chen, A.C.N., Dworkin, S.F., Haug, J., & Gehrig, J. (1989b). Human pain responsivity in a tonic pain model: Psychological determinants. *Pain, 37,* 143-160.

Clark, L.A., & Watson, D. (1991). General affective dispositions in physical and psychological health. In C.R. Snyder & D.R.Forsyth (Eds.), *Handbook of social and clinical psychology: The health perspective* (pp. 221-245). Elmsford, NY: Pergamon.

Clark, W.C. (1969). Sensory-decision theory analysis of the placebo effect on the criterion for pain and thermal sensitivity (*d'*). *Journal of Abnormal Psychology, 74,* 363-371.

Clark, W.C. (1984). Application of multidimensional scaling to problems in experimental and clinical pain. In B. Bromm (Ed.), *Pain measurement in man: Neurophysiological correlates of pain* (pp. 349-369). Amsterdam: Elsevier.

Clark, W.C. (1994). The psyche in the psychophysics of pain: An introduction to sensory decision theory. In J. Boivie, P. Hansson, & U. Lindblom (Eds.), *Touch, temperature and pain in health and disease: Mechanisms and assessments* (pp. 41-62). Seattle: IASP Press.

Clark, W.C. (1996). Pain, emotion and drug-induced subjective states: Analysis by multi-dimensional scaling. In G. Adelman & B. Smith (Eds.), *Encyclopedia of neuroscience* (pp. 1-6). Amsterdam: Elsevier.

Clark, W.C. (2001). *Pain and emotion.* In E.R. Gonzalez, S.J. Myers, J.E. Edelstein, J.S. Lieberman, & J.A. Downey (Eds.), *Downey and Darling's physiological basis of rehabilitation medicine.* Boston: Butterworth Heinemann.

Clark, W.C., & Goodman, J.S. (1974). Effects of suggestion on *d'* and *Cx* for pain detection and pain tolerance. *Journal of Abnormal Psychology, 83,* 364-372.

Clark, W.C., Yang, J.C., Carroll, J.D., & Janal, M.N. (1986). Multidimensional scaling reveals two dimensions of Thermal Pain. *Journal of Experimental Psychology: Human Perception and Performance, 12,* 103-107.

Clark, W.C., Ferrer-Brechner, T., Janal, M.N., Carroll, J.D., & Yang, J.C. (1989). The dimensions of pain: A multidimensional scaling comparison of cancer patients and healthy volunteers. *Pain, 37,* 23-32.

Clark, W.C., Janal, M.N., & Carroll, J.D. (1989). Multidimensional pain requires multidimensional scaling. In C.R. Chapman & J.D. Loeser (Eds.), *Issues in pain measurement* (pp. 285-325). New York: Raven.

Clark, W.C., Fletcher, J.D., Janal, M.N., & Carroll, J.D. (1995). Hierarchical clustering of pain and emotion descriptors: Toward a revision of the McGill Pain Questionnaire. In B. Bromm & J.E. Desmedt (Eds.), *Pain and the brain : From nociception to cognition* (pp. 319-329). New York: Raven.

Clark, W.C., Janal, M.N., Hoben, E.K., & Carroll, J.D. (2001). How separate are the sensory, emotional, and motivational dimensions of pain? A multidimensional scaling analysis. *Somatosensory and Motor Research, 18,* 31-39.

Clark, W.C., Yang, J.C., Tsui, S., Ng, K., & Bennett Clark, S. (2001). *Unidimensional pain rating scales: What do they really measure?* Manuscript under editorial review.

Cleeland, C.R., Gonin, R., Hatfield, A.K., Edmonson, J.H., Blum, R.H., Stewart, J.A., & Pandya, K.J. (1994). Pain and its treatment in outpatients with metastatic cancer. *New England Journal of Medicine, 330,* 592-596.

Cloninger, C.R. (1986). A unified biosocial theory of personality and its role in the development of anxiety states. *Psychiatric Developments, 3,* 167-226.

Cloninger, C.R., Przybeck, T.R., & Svrakic, D.M. (1991). The tridimensional personality questionnaire: U.S. normative data. *Psychological Reports, 69,* 1047-1057.

Cloninger, C.R., Svrakic, D.M., & Przybeck, T.R. (1993). A psychobiological model of temperament and character. *Archives of General Psychiatry, 50,* 975-990.

Davidson, P.O., & Bobey, M.J. (1970). Repressor-sensitizer differences on repeated exposures to pain. *Perceptual and Motor Skills, 31,* 711-714.

Davidson, P.O., & McDougall, C.E. (1969a). Personality and pain tolerance measures. *Perceptual and Motor Skills, 28,* 787-790.

Davidson, P.O., & McDougall, C.E. (1969b). The generality of pain tolerance. *Journal of Psychosomatic Research, 13,* 83-89.

Derogatis, L.R., & Melisaratos, N. (1983). The brief symptom inventory: An introductory report. *Psychological Medicine, 13,* 595-605.

Duncan, G.H., Bushnell, M.C., & Lavigne, G.J. (1989). Comparison of verbal and visual analogue scales for measuring the intensity and unpleasantness of experimental pain. *Pain, 37,* 295-303.

Edens, J.L., & Gil, K.M. (1995). Experimental induction of pain: Utility in the study of clinical pain. *Behavior Therapy, 26,* 197-216.

Eifert, G.H., Schermelleh-Engel, K., Thompson, R.N., Suchday, S., & Gross, R. The pain regulation questionnaire: Reliability and validity of a measure of pain competence, experience, and behavior. Manuscript submitted for publication.

Ellington, L., & Wiebe, D.J. (1999). Neuroticism, symptom presentation, and medical decision making. *Health Psychology, 18,* 634-643.

Endler, N.S., Hunt, J.M., & Rosenstein, A.J. (1962). An S-R inventory of anxiousness. *Psychological Monographs, 76,* 1-33.

Fernandez, E., & Turk, D.C. (1992). Sensory and affective components of pain: Separation and synthesis. *Psychological Bulletin, 112,* 205-217.

Fletcher. J.D. (1997). A multidimensional analysis of the dimensions of physical pain and emotional stress. *Dissertation Abstracts International: Section B: The Sciences and Engineering, 58 (4-B),* 2160. University Microfilms International.

Folkman, S., & Moskowitz, J.T. (2000). Positive affect and the other side of coping. *American Psychologist, 55,* 647-654.

Frid, M., & Singer, G. (1979). Hypnotic analgesia in conditions of stress is partially reversed by naloxone. *Psychopharmacology, 63,* 211-215.

Frid, M., Singer, G., & Rana C. (1979). Interactions between personal expectations and naloxone: Effects on tolerance to ischemic pain. *Psychopharmacology 65,* 225-231.

Geisser, M.E., Robinson, M.E., Keefe, F.J., & Weiner, M.L. (1994). Catastrophizing, depression and the sensory, affective and evaluative aspects of chronic pain. *Pain, 59,* 79-83.

Geisser, M.E., Robinson, M.E., & Pickren, W.E. (1992). Differences in cognitive coping strategies among pain-sensitive and pain-tolerant individuals on the cold-pressor test. *Behavior Therapy, 23,* 31-41.

Gracely, R.H. (1992). Evaluation of multi-dimensional pain scales. *Pain, 48,* 297-300.

Gracely, R.H., McGrath, P., & Dubner, R. (1978a). Ratio scales of sensory and affective verbal pain descriptors. *Pain 5,* 5-18.

Gracely, R.H., McGrath, P., & Dubner, R. (1978b). Validity and sensitivity of ratio scales of sensory and affective verbal pain descriptors: Manipulation of affect by diazepam. *Pain, 5,* 19-29.

Gracely, R.H., & Wolskee, P.J. (1983). Semantic functional measurement of pain: Integrating perception and language. *Pain, 15,* 389-398.

Guastadisegni, P.E., Clark, W.C., Fletcher, J.D., Janal, M.N., & Dworkin, R.H. (1995, November). *Multidimensional affect and pain scale (MAPS) profile of herpes zoster pain.* Poster session presented at the annual meeting of the American Pain Society, Los Angeles.

Hardiness Institute. (1985). *Personal views survey.* Newport Beach, CA: Author.

Harkins, S.W., Price, D.D., & Braith, J. (1989). Effects of extraversion and neuroticism on experimental pain, clinical pain, and illness behavior. *Pain, 36,* 209-218.

Hines, E.A. & Brown, G.E. (1932). Standard stimulus for measuring vasomotor reactions: Its application in the study of hypertension. *Proceedings of the Staff Meeting of the Mayo Clinic, 7,* 332-335.

Hochberg, H., & Benjamini, Y. (1990). More powerful procedures for multiple significance testing. *Statistics in Medicine, 9,* 811-818.

Janal, M.N. (1996). Pain sensitivity, exercise and stoicism. *Journal of The Royal Society of Medicine, 89,* 1-6.

Janal, M.N., Clark, W.C., & Carroll, J.D. (1993). Multidimensional scaling of painful electrocutaneous stimulation: INDSCAL dimensions, signal detection theory indices and the McGill Pain Questionnaire. *Somatosensory and Motor Research, 10,* 31-39.

Janal, M.N, Glusman, M., Kuhl, J.P., & W.C. Clark. (1994). Are runners stoical? An examination of pain sensitivity in habitual runners and normally active controls. *Pain, 58,* 109-116.

Janal, M.N, Glusman, M., Kuhl, J.P., W.C. Clark, & Coromilas, J. (1993). On the absence of correlation between responses to noxious heat, cold, electrical and ischemic stimulation. *Pain, 58,* 403-411.

Joint Commission on Accreditation of Healthcare Resources. (2000). *2001 hospital accreditation standards.* Oakbrook Terrace, IL: Joint Commission Resources.

Keogh, E. & Birkby, J. (1999). The Effect of anxiety sensitivity and gender on the experience of pain. *Cognition and Emotion, 13,* 813-829.

Kobasa, S.C., Maddi, S.R., & Kahn, S. (1982). Hardiness and health: A prospective study. *Journal of Personality and Social Psychology, 42,* 168-177.

Kuhl, J.P., Janal, M.N., Dworkin, R.H., & Clark, W.C. (1996, November). *Differences in sensory and emotional response to painful heat and cold stimulation assessed by the multidimensional affect and pain survey (MAPS).* Poster session presented at the annual meeting of the American Pain Society, Washington, D.C.

Kuhl, J.P., Janal, M.N., Fletcher, D., Guastadisegni, P.E., & Clark, C. (1999, October). *Cold pressor microchronography distinguishes pain-tolerant from pain-sensitive individuals, but not women from men.* Poster session presented at the annual meeting of the American Pain Society, Ft. Lauderdale.

Kwilosz, D.M., Green, D.P., & Torgerson, W.S. (1983, November). *Qualities of hurting: The language of pain.* Poster session presented at the annual meeting of the American Pain Society, Chicago.

Lambert, W.E., Libman, E., & Poser, E.G. (1960). The effect of increased salience of a membership group on pain tolerance. *Journal of Personality, 28,* 350-357.

Lautenbacher, S., Roscher, S., & Strian, F. (1995). Tonic pain evoked by pulsating heat: Temporal summation mechanisms and perceptual qualities. *Somatosensory and Motor Research, 12,* 59-70.

Litt, M.D. (1988). Self-efficacy and perceived control: Cognitive mediators of pain tolerance. *Journal of Personality and Social Psychology, 54,* 149-160.

Lovallo, W. (1975). The cold pressor test and autonomic function: A review and integration. *Psychophysiology, 12,* 268-282.

McNicol, D. (1972). *A primer of signal detection theory.* London: Allen and Unwin.

Melzack, R. (1975). The McGill Pain Questionnaire: Major properties and scoring methods. *Pain, 1,* 277-279.

Melzack, R., & Casey, K.L. (1968). Sensory, motivational, and central control determinants of pain: A new conceptual model. In D. Kenshalo (Ed.), *The skin senses* (pp. 423-443). Springfield, IL. Thomas.

Melzack, R., & Torgerson, W.S. (1971). On the language of pain. *Anesthesiology, 34,* 50-59.

Melzack, R., & Wall, P.D. (1965). Pain mechanisms: A new theory. *Science, 50,* 971-979.

Merskey, H., & Bogduk, N. (1994). *Classification of chronic pain.* Seattle: IASP.

Okun, M.A., Zautra, A.J. & Robinson, S.E. (1988). Hardiness and health among women with rheumatoid arthritis. *Personality and Individual Differences, 9,* 101-107.

Orne, M. (1962). On the social psychology of the psychological experiment. *American Psychologist, 17,* 776-783.

Freeman, H.P., & Payne, R. (2000). Racial injustice in health care. *New England Journal of Medicine, 342,* 1045-1047.

Price, D.D. (1999). *Psychological Mechanisms of Pain and Analgesia*. Seattle: IASP Press.

Price, D.D., Bush, F.M., Long, S., & Harkins, S. (1994). A comparison of pain measurement characteristics of mechanical visual analogue and simple numerical rating scales. *Pain, 56,* 217-226.

Rainville, P., Feine, J.S., Bushnell, C., & Duncan, G.H. (1992). A psychophysical comparison of sensory and affective responses to four modalities of experiment pain. *Somatosensory and Motor Research 9,* 265-277.

Reading, A.E., Everitt, B.S. & Sledmere, C.M. (1982). The McGill Pain Questionnaire: A replication of its construction. *British Journal of Clinical Psychology, 21,* 339-349.

Russ, M.J., Clark, W.C., Cross, L.W., Kemperman, I., Kakuma, T., & Harrison, K. (1996). Pain and self-injury in borderline patients: Sensory decision theory, coping strategies, and locus of control. *Psychiatry Research,* 63, 57-65.

Schalling, D. (1970). Tolerance for experimentally induced pain as related to personality. *Reports from the Psychological Laboratories, The University of Stockholm, #303,* 1-14.

Schalling, D. (1985). Anxiety, pain, and coping. *Issues in Mental Health Nursing, 7,* 437-460.

Schalling, D, & Levander, S.E. (1964). Ratings of anxiety-proneness and response to electrical pain stimulation. *Scandinavian Journal of Psychology, 5,* 1-9.

Schalling, D., Rissler, A., Edman, G. (1970). Pain tolerance, personality and autonomic measures. *Reports from the Psychological Laboratories, The University of Stockholm, #304,* 1-16.

Schermelleh-Engel, K., Eifert, G.H., Moosbrugger, H., & Frank, D. (1997). Perceived competence and trait anxiety as determinants of pain coping strategies. *Personality and Individual Differences, 22,* 1-10.

Sherrington, C.S. (1900). Cutaneous sensations. In E.A. Schafer (Ed.), *Textbook of Physiology.* Edinburgh: Pentland.

Sokal, R., & Michener, C.D. (1958). A statistical method for evaluating systematic relationships. *University of Kansas Scientific Bulletin, 18,* 1409-1438.

Spanos, N.P., Jones, B., Brown, J.M., & Horner, D. (1983). Magnitude estimates of cold pressor pain: Effects of suggestions, cognitive strategy, and tolerance. *Perception, 12,* 355-362.

Spielberger, C.D., Gorsuch, R.L., & Lushene, R.E. (1970). *Manual for the State-Trait Anxiety Inventory.* Palo Alto, CA: Consulting Psychologists Press.

Stam, H.J., Petrusic, W.M., & Spanos, N.P. (1981). Magnitude scales for cold pressor pain. *Perception and Psychophysics, 29,* 612-617.

Suinn, R.M. (2001). The terrible twos -- anger and anxiety: Hazardous to your health. *American Psychologist, 56,* 27-36.

Tajet-Foxell, B., & Rose, F.D. (1995). Pain and pain tolerance in professional ballet dancers. *British Journal of Sports Medicine, 29,* 31-34.

Turk, D.C., & Flor, H. (1999). Chronic pain: A biobehavioral perspective. In Gatchel, R.J. & Turk, D.C. (Eds.), *Psychosocial factors in pain: Critical perspectives* (pp. 18-34). New York: Guilford.

Turk, D.C., Rudy, T.E., & Salovey, P. (1985). The McGill Pain Questionnaire reconsidered: Confirming the factor structure and examining appropriate uses. *Pain, 21,* 385-397.

Vale, V. & Juno, A.(Eds.) (1989). *Modern primitives.* San Francisco: RE/Search Publications.

Van Treuren, R.R., & Hull, J.G. (1987, August). *Hardiness and the perception of symptoms.* Paper presented at the annual convention of the American Psychological Association, New York.

Verkes, R.A., Van der Kloot, W., & Van der Meij, J. (1989). The perceived structure of 176 pain descriptive words. *Pain, 38,* 219-229.

Wade, J.B., Dougherty, L.M., Hart, R.P., Rafii, A., & Price, D.D. (1992). A canonical correlation analysis of the influence of neuroticism and extraversion on chronic pain, suffering, and pain behavior. *Pain, 51,* 67-73.

Wiebe, D.J., & Williams. P.C. (1992). Hardiness and health: A social psychophysiological perspective on stress and adaptation. *Journal of Social and Clinical Psychology, 11,* 238-262.

Weisberg, J.N., & Keef, F.J. (1999). Personality, individual differences, and psychopathology in chronic pain. In R.J. Gatchel & D.C. Turk (Eds.), *Psychosocial factors in pain: Critical perspectives* (pp. 56-73). New York: Guilford.

Willer, J.C. (1983). Nociceptive flexion reflexes as a tool for pain research in man. *Advances in Neurology, 39,* 809-827.

Williams, P.G., Wiebe, D.J., & Smith, T.W. (1992). Coping processes as mediatcrs of the relationship between hardiness and health. *Journal of Behavioral Medicine, 15,* 237-255.

Winer, R.T., Clark, W.C., Keohan, M.L., Wharton, R.N., & Bennett Clark, S. (1999, August). Validati*on of the multidimensional affect and pain scale (MAPS) in cancer patients.* Poster session presented at the triennial meeting of the International Association for the Study of Pain, Vienna, Austria.

Wolff, B.B. (1980). Measurement of Human Pain. In J.J. Bonica (Ed.), *Pain* (pp. 173-189). New York: Raven.

Yang, J.C., Wagner, J.M., & Clark, W.C. (1983). Psychological distress and mood in chronic pain and surgical patients: A sensory decision theory analysis. In J.J. Bonica, U. Lindblom, & A. Iggo (Eds.), *Advances in Pain Research and Therapy: Vol. 5.* (pp. 901-906). New York: Raven.

Yang, J.C., Clark, W.C., Tsui, S.L., Ng, K.F., & Bennett Clark, S. (2000). Preoperative Multidimensional Affect and Pain Survey (MAPS) Scores Predict Postcolectomy Analgesia Requirement. *The Clinical Journal of Pain, 16,* 314-320.

Zborowski, M. (1969). *People in pain.* San Francisco: Jossey-Bass.