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**THREE DIMENSIONAL DRAWINGS
OF
PAIN LOCATION IN CLUSTER HEADACHE**

**Ruth Ann Fraser
Carleton University
Ottawa, Ontario**

**Thesis submitted to the Faculty of Graduate Studies
and Research in partial fulfilment of the requirements for
the degree of
Master of Arts in Psychology**

September, 1992

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**The undersigned recommend to the Faculty of Graduate Studies
and Research acceptance of the thesis**

**THREE DIMENSIONAL DRAWINGS
OF
PAIN LOCATION IN CLUSTER HEADACHE**

Submitted by Ruth Ann Fraser

**In partial fulfillment of the requirements for
the degree of Master of Arts**

Thesis Supervisor

Chair, Department of Psychology

**Carleton University
September, 1992**

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Abstract

This study evaluated three dimensional (3D) drawings of headache. Male subjects ($n = 20$) with episodic cluster headache drew the location of their "typical" cluster headache on a three dimensional, life-size, clear acrylic model of a human head constructed of 95mm horizontal plates that allowed them to consecutively remove layers and draw on the appropriate plates. Using a computer assisted drawing program (CADKEY), these drawings were digitized and solid representations of the headache were produced. The properties of volume, area and centroid were computed for these solids.

Each subject drew headache location at onset and at peak intensity of a "typical" attack. To test for reliability subjects were required to make both drawings on two occasions separated by 5 - 10 days. Significant correlations for test-retest on the volume, area and centroid properties for the 3-D drawings were found. Overall pain scores, psychological state or inherent spatial ability did not influence the volume measure obtained from the pain drawings.

At peak intensity, two regions of headache location (as indicated by the centroids) were identified - one was periorbital ($N = 15$) and the other was temporal ($N = 5$). Temporal headaches occupied a significantly larger volume space than did periorbital headaches. Cluster and discriminant analysis did not suggest that the McGill Pain Questionnaire variables were able to differentiate between these two site locations.

Acknowledgements

My thanks to my thesis supervisor, Professor Jim Campbell, for giving me the original concept of investigating the three dimensional aspects of headache. This has been an opportunity to undertake something that had never been attempted before and I am deeply grateful for Jim's willingness to share his ideas.

Thanks are also due to Dr. Egilius L. H. Spierings, who was at the time of this research, the Director of the Headache Research Foundation of the John R. Graham Headache Centre, Boston. Giel not only had the openness and flexibility of mind to see beyond traditional neurological thought but in very practical ways put the resources of the Headache Research Foundation into this research.

Several individuals in the corporate world have contributed substantially to the completion of this work. Drew Santin of Santin Engineering, Salem, MA produced the acrylic model of the head and after agreeing to do the project at cost, went on to bare the over-budget costs that production required. CadKey in Manchester CT, (in particular, Gary Magoon) gave program and technical support and provided the visual reproductions for the data presented at the Vth World Congress on Headache in Washington, 1991. Wence Daks of CadWire in Toronto gave technical support.

Mostly, and although I do not comprehend it, I am very aware of God's guidance and direction in all aspects of my life and work and I am thankful for all His blessings - one of which is the loving support and encouragement of family and friends.

Part of this thesis was presented as a poster presentation at the Vth World Congress on Headache in Washington in July, 1991 and the abstract published in Cephalalgia.

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Introduction

Meinhart and McCaffery (1983) have noted that the only "real authority on whether an individual is experiencing pain or not is the individual... Pain is whatever the experiencing person says it is, existing whenever he [or she] says it does" (p. 11). In fact, Schoenfeld (1981) has argued that the reality of pain resides solely in the subject's report of it.

Therefore, the key to a meaningful report of pain and indeed, to pain measurement itself, lies in providing an individual with the means to offer an accurate description thus linking the subjective experience with meaningful verbalization (Bucci, 1982). Presently, clinical practice has few standardized procedures to assist the patient in describing the experience of pain. This is particularly evident in the study of headache even though the person's report of symptoms becomes the main support for diagnosis (Lance, 1982, p. 8) when the headache is not accompanied by definitive neurological signs. For the headache history, the physician elicits the qualitative and the quantitative aspects of the person's headache experience - the location, intensity, frequency and duration as well as the triggers, relieving factors and previous treatments.

Part of the headache history frequently includes requesting the individual to draw the location of the headache on a blank two dimensional line drawing of a head

(Bakal & Kaganov, 1976; Blau & Dexter, 1981; Dalessio, 1985, p. 279; Diamond & Dalessio, 1982, pp. 18-26; Fisher, 1968). Nevertheless, headache location has not been viewed as a particularly useful parameter in diagnosis (Friedman, 1979).

One of the reasons for virtually ignoring subjective report on the location of headache may be that these grossly anatomical, two dimensional drawings of pain are not sufficient to assess adequately whether headache location is an important parameter in the study of headache. Headache pain not only covers a surface area but it also involves a depth specification or a volume measurement. This has been independently suggested by both clinical and experimental work. Blau & Dexter (1981) note that patients with headache often report their headache to be "deep-seated".

Experimentally, in a study which evaluated the area associated with migraine headache, Campbell, Brisebois and Hughes (1987) specified that the limitations of the study were the inability to illustrate the depth of the head pain and the spread of the pain over time. The technology to record, store and translate three dimensional information, as it pertains to headache location, into meaningful data has only recently become available. Therefore, this research utilized the available technology and examined patient report of headache location in three dimensional space.

Three dimensional drawings of headache pain location are, in a sense, a novel assessment tool. As such, to

determine how three dimensional drawings of pain location might fit into current pain assessment and measurement methodology, three areas of relevant literature have been summarized.

First, how verbal reports and pain drawings have been obtained, measured and utilized has been critically reviewed. Inherent in the idea of measurement are the issues of reliability and validity. These have been discussed for verbal reports but with particular emphasis on pain drawings, as reliability and validity are relevant in evaluating a novel assessment tool. Since this research methodology called for drawing the location of a "typical" headache, in effect, a "remembered" pain, the literature on memory for pain, has also been reviewed. As well, subjects were requested to draw their headache location in three dimensional space, a technique that empirically demanded some degree of inherent spatial ability. Therefore, a brief discussion of how spatial ability might impact the task has been summarized.

Second, a review of the common headache syndromes gave particular attention to headache location in each syndrome and provided a basis for understanding why cluster headache was chosen as the sample on which to test drawings of headache location.

Third and lastly, with reference to early neurosurgical reports of headache location, these topics have been integrated into a rationale for the study.

Pain Assessment and Measurement

Many discussions (Fordyce, 1983; Torgerson 1984) have focused on whether pain assessment should rely on "objective" or "subjective" measures. Objective measures are, by definition, independent of individual perception and evaluation. The strong implication is that objective measures are more reliable than subjective measures. However, objective measures of physiological or behavioural responses to pain are measures of pain accompaniments, not the actual pain experience. Objective measures based on physiological responses to pain such as blood pressure, heart rate and skin conductance likely reflect the general state of arousal of an individual in acute, intense pain (Dowling, 1983; Elton, Burrowe, & Stanley, 1979). For individuals who suffer from chronic pain, adaptation is observed (Hilgard, 1969) and these physiological measures no longer maintain their correlation with pain intensity. A similar argument may be made about the measurement of brain evoked potentials as indicators of pain perception (Chapman, 1980a, 1980b), but the evidence is not sufficient to draw a definitive conclusion (Polich, Aung, Dalessio, 1987).

Objective measures based on behavioural responses to pain, such as measurement of "down time" or amount of medication used (Chapman, Casey, Dubner, Foley, Gracely, & Reading; 1985), are not necessarily reliable indices of the pain experience although they may produce reliable indices of treatment effectiveness (Gracely, 1985). Behavioural responses are dependent on previous and current experience with pain, conditioning and the meaning of the experience. These responses are also subject to individual manipulation (Huskisson, 1974; Meinhart & McCaffery, 1983). A recent study (Appelbaum, Radnitz, Blanchard & Prins, 1988) corroborates that, in headache patients, there are no significant correlations between measures of pain behaviour (avoidance, complaint and medication usage) and indices of headache - intensity, frequency or duration. In fact, significant negative correlations were found between headache index scores and the avoidance and complaint factors of the Pain Behaviour Questionnaire (PBQ).

Although Schoenfeld (1981) considered that "the reality of pain resides solely in a subject's report of it", the thrust of his paper proposes that pain is a "socially taught verbal response" and as such can be conditioned as any other behavioural response. This accounts for why "a man can talk one way but behave in another." In pain measurement, if one attempts to understand the perceptual experience, then one

is interested, not so much in how one behaves but how one talks and it is only this subjective, introspective measure of pain that offers a way to systematically record and present the experience from the perspective of the individual and enable procurement of not only quantitative but also qualitative data. Subjective judgments, despite the criticism that these may be biased by any number of factors including expectancy, reward or conditioning, have gradually become more accepted. To a large degree, this is due to the methodological advances in psychophysical scaling techniques (McDowell & Newell, 1987, p. 16).

Psychophysics attempts to provide a mathematical relationship between the intensity of the stimulus and the subjective estimation (or the individual's perception) of the strength of that stimulus. The underlying assumption is that individuals can accurately judge the intensity and quality of a stimulus and that, after introspection, they will report this in a conscientious fashion (Chapman, Casey, Dubner, Foley, Gracely & Reading, 1985).

Traditionally, psychophysics was based on measured subjective judgments of stimuli that could also be measured on a physical scale. Fechner's Law utilized natural logarithms to express the relationship between a physical scale such as line length and the subjective judgment of that length. However, Stevens (1960) noted that logarithmic

functions do not accurately describe all relationships between stimuli and perceptual responses. He demonstrated that a power law could be more widely applied to these relationships. Every sensory stimulus tested has been shown to have a different exponent for the power function. This implies that subjective responses to different types of stimuli increase at different, but characteristic rates. As an illustration, pain produced by irradiating the skin with heat has been shown to follow a specific psychophysical power law (Adair, Stevens, Marks, 1968). Thus, individuals have been shown to be able to make consistent, numerical subjective estimates not only on the strength of physical stimuli (McDowell & Newell, 1987, p. 18), but also on private internal sensations such as pain.

As subjective reports have gained general credibility, pain measurement has attempted to embrace and validate subjective report measures, including verbal reports and pain drawings.

Verbal Reports

Historically, subjective pain measurements were based on a unitary concept of pain and focused on the intensity of the pain. Simply put, this meant that pain was viewed as a direct result of tissue damage. Thus, the more extensive the tissue damage, the more intense or severe the pain was expected to be. It is now recognized that pain is a multifaceted experience of perceived sensation that may or may not be related to a particular nociceptive stimulus. Pain has a distinctly unpleasant nature or affective quality that demands attention and relief and yet the behavioral reaction to pain can be modified by past experience, conditioning or an evaluation that pain, in certain instances, may be secondary to the task at hand (Melzack, 1983). Three types of pain expression or verbal reports have been identified by Ehlich (1985). The first, and most basic is the instinctive reaction to cry or groan on painful stimulation. The second speaks of pain interjections. These are short linguistic expressions, such as the expression "ow" that convey meaningful information. The third type of pain expression is pain description that makes use of symbolic terms and involves some type of cognitive analysis. It is this third type of pain expression that is typically "measured" although some attempt has been made to correlate infant cries with pain intensity (Wasz-Hockert,

Lind, Vuorenkoski, Partanen, & Valanne, 1968). Verbal reports of pain have been "measured" utilizing simple verbal rating scales or visual analog scales to measure the intensity aspect of the pain. Various pain questionnaires attempt to measure the multidimensional aspects of the pain experience.

Verbal rating scales.

Keele (1948) defined a four point verbal rating scale (VRS) that described pain intensity as slight, moderate, severe or agonizing. These categories were defined by their behavioral and emotional accompaniments. For example, slight pain was defined as "awareness of pain without distress" while severe pain "fills the field of consciousness to the exclusion of other events". Currently, it is more common to view the sensory intensity component as separate from the behavioral reaction component. As well, the "agonizing" term has subsequently been dropped and the intensity scale of mild, moderate and severe has remained the most popular scale for simple assessments of pain.

The disadvantages of this type of scale are threefold. First, it lacks sensitivity in that it forces the subject to choose a nominal category that may not accurately reflect the actual level of intensity; i.e., one cannot choose moderately-severe but must choose between moderate or severe. Second, Hardy, Wolff & Goodell (1948) demonstrated

that individuals are able to discriminate between 21 just noticeable differences (JND) in pain sensation. This would suggest that individuals are capable of providing far more discriminative ability than a 3-point scale can obtain. Third, the relative size of differences between the nominal categories varies. While the term "mild" has been interchangeably substituted for "slight", an analysis of words used to describe pain found a significant level of difference in visual analog scale values ascribed to these terms (Sriwatanakul, Kelvie & Lasagna, 1982). These differences in categorical judgments have been corroborated by Heft & Parker (1984). In the assessment of headache symptomology, interval ratings have been found to be more reliable and more sensitive than dichotomous scales (Thompson & Figueroa, 1980; Waters, 1978).

Visual analog scale

Discrimination of changes in intensity is improved with the use of either a visual analog scale (VAS), graphic rating scale or numerical rating scale (Downie & Leatham, 1978; Huskisson, 1983). Most familiar is the VAS, a horizontal or vertical line scale, usually of 10 centimetres length, with one endpoint marked as "No pain" and the opposite endpoint marked as "Pain as bad as it could possibly be" (Scott & Huskisson, 1976) or "Unbearable pain" (Quiding, Oksala, Happonen, Lehtiamaki & Ojala, 1981).

Scott & Huskisson (1976) have made several valuable suggestions as to the best formats that visual analog or graphic rating scales should take with respect to uniformity of distribution of response and ease of patient comprehension.

Visual analog scales have generally been shown to correlate reliably with verbal descriptive scales and have been accepted to be more sensitive than the simple verbal descriptive pain scales in that they do not artificially categorize pain scores (Downie & Leatham, 1978; Heft & Parker, 1984; Huskisson, 1983; Omnhaus & Adler, 1975; Woodforde & Merskey 1972). The VAS has also been found to be reliable in test-retest experiments with correlation coefficients ranging from .95 - .97 (Revill, Robinson, Rosen & Hogg, 1976).

Using cross - modality matching, Price, McGrath, Rafii & Buckingham (1983) have argued that visual analog scales of both sensory intensity and affective magnitude are valid as ratio scales in chronic and experimental pain. Although some have argued that subjective scales are never of an interval level but only a nominal level, the analog scales have been considered to have at least interval properties thus enabling parametrical analyses to be carried out legitimately (McDowell & Newell, 1987, p. 16).

Pain questionnaires.

While the descriptive and visual analog scales are common indices of sensory pain intensity, they do not address the qualitative aspects of the pain experience. The sensation of pain produces a qualitative reaction that includes an emotional or affective response as well as an evaluative response, i.e. what meaning can be ascribed to this experience (Melzack & Torgerson, 1971). Pain questionnaires, such as the Pain Perception Profile (PPP) (Tursky, Janner & Friedman, 1982) and the McGill Pain Questionnaire (MPQ), (Melzack, 1975) are able to address the multidimensional nature of the pain experience and thus have been recommended (Andrasik, Blanchard, Ahles, Pallmeyer & Barron, 1981; Johnson & Rice, 1974; Reading, 1980; Reading, Hand & Sledmere, 1983). Questionnaires specific to headache assessment have also been developed - specifically, the Headache Assessment Questionnaire (HAQ) (Bakal, 1982) and the Headache Scale (Hunter, 1983).

The Pain Perception Profile represents a psychophysical approach to quantitatively scaling the sensory, affective and intensity components of pain. Tursky used magnitude estimation and cross modality matching procedures to create a pain profile for each individual that reflected individual levels of sensation, discomfort, pain and tolerance. It has not been used extensively since it demands considerable

input in terms of both time and effort. No extensive data on its reliability or validity are available (McDowell & Newell, 1986).

The McGill Pain Questionnaire (MPQ) has been described as one of the first comprehensive, multidimensional pain measurement tools that integrates the cognitive-evaluative, motivational-affective and sensory-discriminative aspects of pain. It has been accepted for its reliability (Melzack, 1975; Reading, 1983; Reading, Everitt & Sledmere, 1982), and its construct and discriminant validity (Byrne, Troy, Bradley, Marchisello, Geisinger, Vander Heide, & Prieto, 1982; Kremer & Atkinson, 1981; Melzack, Wall & Ty, 1982; Reading 1982). The MPQ has been applied to the assessment of many types of chronic and acute pain conditions and has also been employed as a self-report measure (Melzack, 1983).

In headache diagnosis, the value of the McGill Pain Questionnaire has been demonstrated independently by Hunter and Philips (1981) and Allen & Weinmann (1982). Both groups used the verbal descriptors of the McGill Pain Questionnaire to differentiate between muscle contraction and migraine headaches even though these headaches have many verbal descriptors in common. Most recently, cluster headache has been distinguished from other types of vascular headache syndromes by higher scores on a 0 - 100 scale for intensity and on the affective dimension of the MPQ (Jerome, Holroyd,

Theofanous, Pingel, Lake & Saper, 1988). The MPQ also differentiated between these headache classifications on the basis of which subcategories were selected, i.e. the qualitative descriptors chosen for cluster headache differed from those chosen for the other vascular classifications of headache with respect to spatial, punctate, incisive, traction and thermal qualities.

However, Jerome et al (1988) were not able to replicate the findings of Hunter & Philips (1981) or Allen & Weinmann (1982) in differentiating between migraine and muscle contraction headaches. This may be due to the continuing classification controversy (Ad Hoc Committee, 1962; Bakal, 1982; Capildeo & Rose, 1982; Martin, 1985; Ziegler, 1979) and the fact that different investigators utilize different classification schemes. The most detailed and most recent (1988) classification system arises from the International Headache Society (IHS) and its use has been recommended for research purposes. Its limitations are, however, consistent with the limitations of the Ad Hoc Classification for Headache, since both have been derived from suggestions and conclusions of primarily medical practitioners who operate/classify based on a variety of theoretical bases. Both classification schemes therefore represent an overall consensus of subjective, albeit expert, opinion. Clinical observations from many disciplines

suggests that the experience of headache is considerably richer than standard classification schemes permit (Ziegler, Hassanein, & Hassanein, 1973).

Due to the discrepancy between the number of subcategories in the MPQ between the sensory (14), the affective (5) and the evaluative (1) dimensions, it has been difficult to compare the relative contribution of each dimension to the overall score (Charter & Nehemkis, 1983). Therefore, Hunter (1983) adapted the MPQ to form The Headache Scale for the assessment of subjective headache pain. From the MPQ, twenty seven descriptors were chosen by headache patients as reflective of their headache experience. Three additional qualitative descriptors were added. Using cluster analysis, Hunter classified these 30 descriptors into 5 sensory clusters (aching, sharp, tight, autonomic, dull) and 2 affective (anxiety/depression, discomfort) clusters. Each qualitative descriptive was presented and rated on a categorical 0 - 3 (none, mild, moderate, severe) scale.

In the aforementioned study, the problem of directly comparing sensory and affective dimensions was not originally addressed. A second study (Jahanshahi, Hunter & Philips, 1986) found the Headache Scale to have a satisfactory level of test-retest reliability ($r = .75$, $p < .001$) and to demonstrate concurrent validity by

statistically significant intercorrelations of the Headache Scale with the MPQ. As well the Headache Scale demonstrates similar patterns of associations as the MPQ to measures of pain behaviour, depression and personality. Since affective and sensory components become more highly correlated with increased severity, when headache intensity was controlled for, cluster analysis revealed an even split in verbal descriptors for both the sensory and the affective dimensions, thus addressing the problem of direct comparison of the sensory and affective components of the headache experience.

The greatest disadvantage to the Headache Scale is that the verbal descriptors chosen from the MPQ as representative of headache were chosen by patients who represented only the diagnostic groups of migraine and tension type headache. While these groups form the largest percentage of headache sufferers, the descriptors of the Headache Scale may not adequately represent other groups of headache sufferers.

The Bakal Headache Assessment Questionnaire (HAQ) was developed to assist in the therapeutic management of chronic headache when approached from a cognitive-behavioral perspective. While this questionnaire has shown itself to have construct and discriminant validity (Penzien, Holroyd, Holm & Hursey, 1985), it does not address the sensory and affective dimensions of headache experience but does address

several psychological dimensions that are implicated in the management of headache. The HAQ arises out of a paradigm that hypothesizes that similar psychobiological processes underlie all headache disorders and that headache is best represented by a continuum with occasional, mild, non-problem headaches on one end and chronic, severe, problem headaches on the other. The HAQ successfully differentiates between high and low frequency headache sufferers. In the study done by Penzien et al (1985), the HAQ was only significantly correlated with the evaluative and the intensity score from the MPQ and even these correlations were not large. This suggests that the HAQ is measuring a different construct than the MPQ. Higher correlations were found with other psychological indices such as locus of control and self-efficacy.

Pain Drawings

Pain drawings or pain charts are two dimensional drawings of either the whole body or the part that is of interest. The need for further utilization of pain drawings as well as for new visualization techniques has been recommended in order to assist the patient in communicating both the extent and the type of symptoms experienced (Margoles, 1983). Pain drawings have several advantages. They allow the patient to communicate to the therapist, not only the location but also other components of the

experience that may be difficult to verbalize, e.g., areas of numbness, tingling or burning. While Margoles (1983) concluded that acute pain tends to be more localized than chronic pain, pain drawings may also be useful in documenting the extension of disease or the response to treatment regimens.

Pain drawings are, in a sense, a subjective, self-imaging assessment. Nevertheless, as Williams (1988, p. 240) noted "The real issue is not how measures are obtained but how reliable and valid they are."

Reliability of pain drawings.

However, a review of the literature reveals a scarcity of reports or studies evaluating the reliability of pain drawings. Although pain drawings are used to describe the location of chronic back pain (Uden & Landin, 1987) or headache (Bakal, 1982), only Margolis, Chibnall & Tait (1988) report that the test-retest reliability of a two dimensional pain drawing instrument is highly reliable for both ratings of percentage of body surface involved ($r = .85$, $p < .001$) and for site distribution (i.e. areas indicated as painful at Time 1 were also indicated as painful at Time 2 with a percentage agreement of 76%).

Most of the work with pain drawings seems to have assumed their reliability. In spite of this untested but accepted assumption, pain drawings have been used in

research studies - and particular interest has focused on how pain drawings can be related to the psychological state, particularly in studies of chronic back pain. Ransford, Cairns & Mooney (1976) postulated that patients with back pain whose drawings deviated from accepted patterns of pain location and referral were individuals whose pain experiences were overlaid with psychological factors. The pain drawings were scored by a penalty rating system whereby the patient incurred one penalty rating each time the pain drawing was not anatomically accurate.

Anatomical inaccuracy was defined as "unreal drawings" with poor anatomical localization, "drawings showing magnification or expansion of the pain", and indicators that said "I particularly hurt here". These authors found that the penalty ratings were highly correlated with the hysteria and hypochondriasis scales of the Minnesota Multiphasic Personality Inventory (MMPI). In an attempt to replicate this study, Von Baeyer, Bergstrom, Brodwin & Brodwin (1983) found inter-rater reliability estimates of $r = .97$ for ascribing penalty ratings, however, they did not support the use of pain drawings to indicate psychological distress since the penalty ratings misclassified approximately one-half of the patients whose MMPI scales were within normal range. Margolis, Tait & Krause (1986) transported a body surface rating system commonly used for burn assessment

injuries and divided the pain drawing of the full human figure into 45 anatomical areas. Inter-rater reliability for assessing these pain drawings ranged from .95 - .99 using a variety of statistical methods.

Although headache drawings are commonly a part of the diagnostic or research workup, the value of headache drawings has not been assessed and no studies have been done to indicate whether or not increased spatial distribution of headache pain is a useful discriminator of psychological dysfunction.

Migraineurs describe different spatial and temporal sensations that are well described in the literal if not figurative sense (Dalessio, 1980; Sachs, 1985). Bakal & Kaganov (1976) suggested a simple diagram on which to note the spatial distribution of headache. Pain questionnaires such as the MPQ that utilize full body figures or even figures of heads (Graham, 1963; Travell, 1983, p. 50) are not sufficiently detailed to be useful in describing the precise location of head pain. Margolis et al (1986) has found that the body surface system is inadequate in assessing headache and suggested that a more detailed divisional figure such as the rating system as developed by Toomey, Gover & Jones (1983) should be used. However, the divisions suggested by Toomey et al (1983) have been assigned to provide relatively consistent reference points

even though they are not related to underlying anatomical structure (such as vascular distribution) or to dermatomal sensory innervation. Work by Poletti (personal communication, March 4, 1989; 1991) has suggested that the current understanding of the dermatomal sensory innervation of the head may not be accurate. It may well be that pain location charts need to integrate dermatomal innervation with the pain drawing charts.

In an attempt to more accurately assess the relationship of spatial distribution of head pain with other headache symptoms, Campbell, Brisebois and Hughes (1987) utilized a life-size three-dimensional model head that was covered with a putty substance. Subjects drew on the putty the area(s) that best illustrated the location of their headache. The putty was then removed and flattened to a 2-D plane from which the area was computed using a digitizing tablet. Subjects also completed a headache symptom checklist. This procedure was repeated within one week of their next migraine episode. These investigators found that subjects with symptoms of classic migraine (as defined by the Ad Hoc Committee) cluster into two subsets. Subjects reporting small areas of pain described their head pain as qualitatively different (sharper, more piercing) than those subjects who reported larger areas (pounding, heavy). Other symptoms that differentiated the two clusters were

bilaterality of pain at onset, pain in the jaw region, pain spreading to the whole head as time progressed, osmophobia, and sweating. Campbell et al (1987) did not find that these differentiating symptoms fit into any pattern and they cautioned that this may have been the result of the small sample size and the heterogeneous nature of the sample. Although reliability was not specifically addressed by Campbell et al, it is of interest to note that the locations of pain sites in individual subjects did not change significantly (less than 2 centimetres) between headache episodes. Responses on the symptom checklist were also highly correlated between episodes. This would imply that subjects are able to reliably define the location of their headache, when it was most intense, on the exterior of a three-dimensional head. The specified limitations of the study were the inability to illustrate the depth of the head pain and the spread of the pain over time. This research is an extension of the above research and illustrates the depth and thus the volume associated with the headache experience. Storey (1988) added scaling of the pain intensity to the procedure recommended by Campbell et al (1987). Although Storey reported that subjects were able to show reliably that pain intensity decreased systematically from a central point of maximum intensity to the outer reaches of the pain area, this research did not incorporate that methodology.

Validity of pain drawings.

Pain measurement is not only concerned with the issue of reliability but also with validity. Validity is most commonly defined as the extent to which a test measures what it is intended to measure. Asking subjects to report on where their headache pain is located has inherent face validity and empirically makes sense. If area is a measurement derived from height and width measurements of a two dimensional model such as used by Campbell, Brisebois & Hughes (1987), then a volume measurement would incorporate the depth perspective of a three dimensional model.

Face validity of pain drawings may be enhanced by the thoughtful perceptions of the artistic community. Despite the emphasis in the majority of headache studies on having accurate pictorial representations of pain location, pain drawings may also be considered a form of art. In art history, there are drawings that depict places, locations and events. These may be as primitive as the old Indian rock paintings found along the Ottawa River or as detailed as the landing of the Mayflower at Plymouth Rock. These drawings depict essentially what the visual sensory system has perceived. Then there are also those works of art that convey, not only what is perceived, but also reflect the "passions of the soul" (Procacci, 1988) - or, in other words, the emotional or affective state.

In an effort to more fully understand patient experience in headache, some innovative approaches to pain drawings have been undertaken recently. In the early 1980's, the British Migraine Association sponsored the National Migraine Art Competition. Individuals who suffered from migraine were asked to draw "their own impressions of any of the forms of visual disturbance which heralded a classical migraine attack or to depict the effect migraine has on their lives" (Wilkinson & Robinson, 1985). From another perspective, these individuals were being asked to draw their sensory (visual) experience or the affective and evaluative experience (effect of migraine on their life).

Visual disturbances are common to migraine sufferers, and specific visual disturbances such as scotomata (see Note) actually help define the classification known as migraine with aura - or, as more commonly known, classic migraine. What was most remarkable was that these art works were very similar in content and resembled pictorial descriptions of these phenomena that were recorded by nineteenth century neurologists. This exhibition led researchers to discover a link between the scotomata experienced by many migraineurs and the microscopical

Note: scotomata Islandlike blind gap in the visual field - may be a dark patch with a zigzag outline (fortification spectrum) or a luminous area bounded by zigzag lines (teichopsia).

anatomical organization within the visual cortex (Wickelgren, 1989). Other than pain, the effect of migraine on their life was only shown in 11% of the pictures. Thus the physical, sensory aspects seemed to be most easily depicted.

Cadenhead (doctoral dissertation, 1985, Boston University) felt that "the artist/migraineur gives another dimension to the field of migraine research through his capacity to convert that which he experiences into art and demonstrate that view to a wide audience". After reviewing an exhibition of art produced by New England headache sufferers, Kudrow, a prominent neurologist in the field of cluster headache management, suggested that "patient created art might offer researchers a new window into the blind spot, perhaps indicating the spot's brain location and revealing the direction of its electrical movement inside the brain" (Wickelgren, 1989).

It is in the works of figurative art that Procacci (1988) has observed "that in many cases, it is difficult to distinguish physical pain from psychic pain". When pain drawings are utilized in pain measurement, controls must be established to assure that the patient's response reflects the information being requested and the investigator must be assured that the individual is not evaluating a reactive component of the experience. This may be achieved in large

part by the instruction set given to the patient (Blitz & Dinnerstein, 1968 & 1971; Hardy, Wolff & Goodell, 1948).

The issues of reliability and validity raise the question of what is actually being tested when performing a test-retest reliability. Is memory for pain tested (ie recall of the actual experience and in a sense re-describing it) or memory for what was scored or selected on the previous test? Or a mixture of both? One might argue that this issue remains controversial.

Memory for Pain

Memory research has focused on visual or auditory sensory memory - and most has focused on semantic memory or the memory for letters or words, their meaning or the concepts the words engender. Very little research has examined episodic memory - memory for definite events (Houston, 1981). Pain that is remembered as a definite, dated event falls into the category of episodic memory. The thoughtful consideration of how well pain is remembered or how reliably remembered pain is reported has only been recently noted in pain literature (Erskine, Morley & Pearce, 1990).

The experimental study of memory for pain, subject to standardized conditions, is not without inherent difficulty - not only is there an ethical issue surrounding the deliberate presentation of painful stimuli, there is

question of whether experimentally induced pain can approach the significance of clinical pain (Chapman et al, 1985). Methodologically, a problem in measurement is evident since most studies rely on the subject's descriptions - usually verbal - and even though studies may be prospective as well as retrospective, retrospective recall may be tapping the individual's memory for the category, number or verbal descriptor rather than memory for the sensory experience *per se*.

Interestingly, the test - retest reliability study by Revill et al (p. 10, 1976) attempted to differentiate between rating a pain experience which was distant in time with simply remembering where the mark on the visual analog scale had been placed at baseline. Both situations gave similar correlation coefficients and Revill et al concluded that subjects "can easily remember where they made the first mark." However, Revill et al conclude the "rating a pain is unlikely just to depend upon remembering where the initial mark on a line was made" because they found significant differences in the variances between repeated ratings of a recalled pain and the variances of the repeated random mark.

In this current study, the methodology requested subjects to remember the location of a typical cluster headache; therefore, it was pertinent to the design of this study to review those papers that had addressed memory for

pain. Second, although this research does not test the reliability of remembered pain, the results of this research suggest how memory for pain, particularly cluster headache pain, might best be integrated into a neuropsychological memory model.

Historically, inaccuracies in describing the pain experience have been attributed to errors in memory (Keele, 1948) although Jones (1957), suggested that since re-living a painful experience is difficult, pain recall of the actual sensation experienced is poor due to a deliberate repression of painful events. This psychoanalytic explanation has been questioned by Merskey (1975) who quotes research that suggests that "pain traces" or "mnemic traces" can be set down both peripherally and centrally after an episode of acute pain and that these mnemic traces can be reactivated by physiological or psychological stressors. This was the first report of any theoretical attempt to integrate pain and memory psychobiology.

The studies that address the issue of remembered pain include both chronic and acute pain. A recent review of the literature on memory for pain (Erskine, Morley & Pearce, 1990) did not find any studies on memory for pain in patients with chronic episodic pain such as experienced in migraine or cluster headache. However, they note that studies on memory for pain can be classified into

essentially two groups - those that address the question of the reliability of recall and those that address the question of what factors might influence the reliability. A selection of relevant papers will be reviewed chronologically.

Reliability of recall.

One of the first investigations into memory for pain was with individuals who experienced an acute headache episode after a minor neurosurgical investigation (Hunter, Philips & Rachman, 1979). Although these investigators hypothesized that the accuracy of pain recall would decay over time, individuals were able to recall their headache both accurately and reliably when re-assessed with the MPQ one to five days after the acute episode with Spearman's rank order correlations of .88 to .97 for the Pain Rating Index score and $r = .76$ to .94 for the Present Pain Intensity score. Thus over a relatively brief timespan, the report of pain when it is experienced and when it is recalled appears to be reasonable stable.

Over a longer period of time (3 months), Thompson & Collins (1979) have reported that college students who suffer from severe, recurring headaches tend to be less reliable in reporting headache severity and accompanying symptoms than students who do not have a headache problem.

Nor did self-monitoring with daily headache diaries improve the reliability on the headache questionnaire.

In a study of individuals with tension headache, Andrasik & Holroyd (1980) compared outpatients with a mean headache duration of about 10 years with a college student sample. The reliability of a brief headache questionnaire assessing frequency, intensity and duration of headache gave Pearson product moment correlations of .84, .66 and .77 respectively. This study also evaluated whether recall data obtained by the headache questionnaire matched that obtained by daily headache records. In the outpatient group, there was minimal correspondence between the questionnaire obtained at pretreatment and the daily recordings obtained in the subsequent two weeks.

While this might give cause to question the validity of patient report on recall, the design of the experiment was not without problems. First, the methodology for the outpatient group was different than that for the college sample. Outpatient scores were a composite of intensity and duration while the college student scores on these measures were not combined. Second, the outpatient group was administered the questionnaire asking about retrospective data and then asked to make prospective daily headache recordings.

However, the college sample took daily headache recordings over a two week period and then were requested to recall the frequency, intensity and duration of headaches experienced over the study period. Significant correlations were obtained between the daily headache recordings ($r = .71$, $p < .0001$) and the retrospective recall the frequency of headache measure. Recall of intensity or duration measures did not reach significant correlations with the prospective daily recordings. Recall for the qualitative aspects of the headache (i.e. verbal descriptions) was not investigated.

The reason for the difference between these two samples may be that subjects awaiting treatment or enrolled in a treatment program might be expected to have a change in pattern based on treatment or expectancy effects (Jensen, Turner, & Romano, 1991).

In another study, the same difficulty with expectancy or treatment effects arises. Linton & Melin (1982) evaluated 12 patients in a rehabilitation program for chronic back or joint pain and found that these patients consistently and significantly overestimated baseline pain intensity ratings when asked to recall their original estimations made on a 0 - 100 numerical scale 3 - 11 weeks previous. These overestimations did not appear to be related to either degree of improvement or recall interval.

A subsequent study with a further 15 patients (Linton & Gotestam, 1983) replicated these results since the numbers in the initial study were small. The second study compared baseline and retrospective assessments (4 - 9 weeks after baseline) using both a 6-point verbal rating scale defined by behaviour and a visual analog scale. Similar results to the first study were obtained in that patients, using the VAS, systematically overestimated their recalled pain intensity levels. The 6-point scale produced both overestimations and underestimations of original pain scores. The authors therefore recommended the 6-point behavioural pain intensity scale as the scale of choice in assessing remembered pain. The difficulty with behavioural pain intensity scales is that pain intensity has never correlated well with functional ability or behavioural indices (Turk & Flor, 1987).

In 1983, Pakul and Milvidaite examined patient memory for acute coronary pain. This interesting study attempted to relate the subjects' memory for their coronary pain (as measured by a VAS and a 9-item list of pain intensity descriptors) with experimentally induced pain at two time points. The first time point for measurement was 4 - 15 hours after the coronary pain and the second, 2 weeks later. The overall mean did not show significant difference in VAS or in pain intensity descriptors. Although the numbers were

small in each group, there appeared to be a trend in that subjects with a less morbid diagnosis (unstable angina, subendocardial myocardial infarction) showed less consistency and greater standard deviations than those subjects who had either a previous experience with myocardial infarction or who had infarcted with their bout of acute coronary pain. One of the immediate criteria for diagnosis of myocardial infarction is consistent severe chest pain lasting more than 15 minutes and unrelieved by nitroglycerin. This type of pain has a distinctness or a vividness about it. Shedler & Manis (1986) suggest that an event may be more easily retrieved from memory when the event is more accessible and it raises the question as to whether more vivid material such as an acute episode of pain is more easily remembered.

A study by Roche and Gijsberg (1986) is pertinent to this question of recall of acute versus chronic pain. The episode of acute pain was induced by a modified tourniquet technique producing ischaemic pain. Chronic pain was evaluated using an inpatient population of rheumatoid arthritics awaiting single joint surgery for the relief of their pain. The McGill Pain Questionnaire was administered to the ischaemic pain group within 2 - 3 minutes after each individual had reached tolerance. Rheumatoid patients were administered the MPQ one day prior to surgery. Both groups

were interviewed and asked to recall their pain at 7 days. Although the correlations between test and retest for the composite sensory and affective MPQ scores were significant for both acute and chronic pain, memory for the single acute episode of pain was superior to that of the chronic rheumatoid pain. In evaluating the component scores of the MPQ, the reactive component had lower test-retest correlations than did the sensory component.

Due to the continuing controversy surrounding the validity of retrospective pain reports, pain intensity recall was examined at 24 and 48 hours after knee ligament reconstruction surgery (Babul, Darke, Johnson & Charron-Vincent, 1992). Patients rated pain intensity hourly for 48 hours and then rated their recall of worst, least and usual pain intensity at 24 and 48 hours. Worst, least and usual pain recall measures were significantly and highly correlated with the respective corresponding prospective pain scores of maximum, minimum and mean. Furthermore, the pain recall measure of "usual" pain was able to significantly discriminate between different analgesic treatment groups in this trial.

Overall, these reports on the reliability of pain memory seem conflicting. Acute pain would appear to be more easily remembered but factors that bias or affect memory or reporting procedures may influence pain recall.

Factors influencing reliability of recall

Although Hunter et al (1979) found that memory for acute headache pain was usually quite accurate, some patients who had high affective scores on the MPQ recalled their pain quite differently than they had originally reported. Hunter et al described these individuals as "shifters" and suggested that a high affective component might contribute to the distortion of pain memory.

Others have suggested that memory for past pain is dependent on the intensity of present pain (Eich, Reeves, Jaeger & Graff-Radford, 1985). In a sample of headache patients, these authors reported that patients consistently remembered and rated previously experienced pain as more intense when their present pain intensity was high and less intense when their present pain intensity was low.

In 1989, Jamison, Sbrocco & Parris evaluated the influence of a number of physical and psychosocial factors on the accuracy of pain memory. These investigators examined a moderately large number of chronic pain patients (N = 93) who had a variety of pain problems and who were being enrolled in a pain treatment program. Patients were requested to complete hourly records on pain intensity for a period of a week. At the end of this week they were asked to recall their average pain intensity for four timepoints each day over that previous week. Accuracy for pain memory

was calculated by subtracting the total mean daily record intensities from the total mean pain recall estimates. On recall, almost 60% of patients tended to overestimate their pain intensity; however, the authors neglect to mention by how much or whether these differences were significant. Mean daily record intensities were significantly correlated with the recalled estimates with a Pearson product moment correlation of $r = .85$, $p < .001$. A stepwise multiple regression analysis revealed that constant pain, less formal education, shorter pain duration, unemployment, frequent bedrest and other family members with pain problems were the factors that were most predictive of pain intensity estimates and accounted for 55% of the variance in the analysis ($\text{adj } R^2 = .49$, $F = 9.76$, $p < .0001$). Overestimation of pain recall was related to pain not due to an accident, aggravation of pain when standing, abnormal medical examination and the use of tranquilizers. Unlike the study by Eich et al, current pain ratings did not seem to influence recall. People who reported higher pain ratings were most accurate in estimating their pain.

While the above studies relate to physical and psychosocial factors that affect memory for pain, the influence of anxiety on memory for dental pain was studied by Kent in 1989. Dental patients were requested to complete a questionnaire containing a dental anxiety scale (DAS)

prior to the dental visit as well as a present affect reactions questionnaire before and after the visit. In addition, as a memory task, patients were requested to describe any previous incident that influenced dental visitation and to rate the pleasantness/unpleasantness of that incident. One half the patients completed the memory task prior to the dental visit, when anxiety levels were believed to be higher - and the other half completed the task after the dental visit. Based on the DAS scores, patients formed 3 groupings of low, moderate and high anxiety. As predicted, there was a significant reduction in anxiety from before to after the dental visit. Patients with higher levels of anxiety rated the memory task as significantly more unpleasant than those with low levels of anxiety - for females the memory task was rated as significantly more unpleasant before the appointment than after. Vividness of description was judged independently and moderate to high anxiety groups scored significantly higher on this variable than did the low anxiety group.

Recently, Erskine, Morley & Pearce (1990) suggested that there is a need for studies in memory and pain to integrate research findings with a theoretical model of memory. A followup study was based on Bower's associative network theory (Pearce, Isherwood, Hrouda, Richardson, Erskine, & Skinner; 1990) and concluded that mood congruity

effects (subjects with chronic pain were more likely to remember pain-related words than subjects without pain) are more related to chronic pain patients than to the effect of learning the words while in the state of pain. These authors indicated that "no attempts have been made to investigate processing errors or specific memory biases in pain patients".

One processing error that might have borne relevance to the reliability of three dimensional drawings is an individual's ability not only to remember the location of their headache pain but to take that self-image or mental representation and to mentally transform it and draw it out on a head model. A very brief review of spatial ability follows.

Spatial Ability

Spatial ability has been defined as the ability to judge "concrete spatial relations". Factor analytic studies of tests of intelligence and mechanical aptitude have revealed at least two spatial factors - visualization and orientation but it has been suggested that these two factors may involve multiple processes (Linn & Peterson, 1985; McGee, 1979, 1982). The extent to which the numerous tests of spatial ability tap into the same dimension(s) is not known.

The ability to obtain and utilize by manipulation or rotation of two and three-dimensional mental representations is spatial visualization. This may also involve movement within the representation (Newcombe, 1982). Spatial orientation is the ability to remain unconfused when a complete spatial pattern is presented in differing orientations (McGee, 1979, p. 54; Newcombe, 1982). Both of these tasks are likely necessary to draw in three dimensional space.

While differences in spatial ability between the sexes have been found, there is much controversy over why this is, when it occurs and whether the differences are significant (Linn & Peterson, 1985; McGee, 1979, p. 42). Sex-related differences in spatial ability have been inconsistently demonstrated prior to puberty but relatively consistently in favour of males after puberty and increasing with age until adulthood. One hypothesis is that spatial ability may be associated with an X-linked recessive gene (McGee, 1982) although the expected patterns of intrafamilial correlations for this type of inheritance have not been borne out (p. 207). Because of the more consistent findings after puberty, a hormonal influence has also been suggested although the mechanism for this is not clear. The issue of hemispheric specialization (females having a bilateral operation of linguistic and visuo-spatial

functions while males operate primarily in the left hemisphere for linguistic operation and right hemisphere for visuo-spatial functions) remains controversial as well. In the old question of "nature versus nurture" some have hypothesized an environmental reason for the male-dominated characteristic of spatial ability - boys having more opportunity and encouragement in activities that demand the development of their inherent spatial abilities.

For the purposes of this study which required individuals to describe their head pain in three dimensions, gender was controlled for in order to avoid a possible sex-related confound.

Common Headache Syndromes

A major re-classification of headache disorders has recently been published (International Headache Society, 1988). The first three classifications list the most common headache syndromes that are generally considered benign: tension-type, migraine and cluster headache. A review of these various headache syndromes with particular reference to headache location assisted in the sample selection for this research.

Tension

Prior to the recent IHS re-classification, tension headache was synonymous with muscle contraction headache, stress headache or psychogenic headache. The new

classification groups tension-type headache according to frequency (episodic vs chronic) and with or without associated pericranial muscle tenderness.

Tension-type headache is defined by the tight or pressing, band-like or cap-like sensation on the scalp that is mild to moderate in intensity. Nausea is characteristically absent, but light or sound sensitivity may be present. Most authors (Dalessio, 1980, pp. 368-378; Lance, 1982, pp. 100-120; Riley, 1983, pp. 489-500) generally relate this type of headache to the stresses associated with an individual's lifestyle and their coping mechanisms (or lack thereof). Tension headache is usually bilateral and although the location of the head pain varies, it is most often first noticeable in the neck, shoulders, or occiput and then spreads to the frontal region. Thus its location tends to become generalized. The pain is usually described as dull, persistent and varies in intensity throughout the headache course (Dalessio, 1980). Treatment is directed at developing coping skills.

Migraine

The Ad Hoc Classification subclassified the common vascular headaches into classic migraine, common migraine, hemiplegic/ophthalmoplegic migraine and cluster headache (Ad Hoc Committee, 1962). While classic and complicated migraine have multiple reports and detailed descriptions on

the types of visual hallucinations or scotomata or visual defects that present themselves (Sachs, 1985, pp. 55-102), there are only broad references to the localization of the headache that accompanies these. Indeed, the localization is often described as quite variable.

Migraine with aura (previously called classical, ophthalmic, migraine accompagnée) is composed of two distinct stages. The first, or prodromal stage, is most typically characterized by unusual visual disturbances that signal the onset of the migraine attack. The visual disturbance (or aura) may last from a few minutes to as long as an hour. These visual symptoms range from blank spots in the visual field, to brightly flashing lights that zigzag across the person's visual field. Many artists and authors have attempted to picture with words or drawings with some startling results (Wilkinson & Robinson, 1985). The aura may not be visual symptoms but may rather involve other sensory systems such as touch, taste, smell or hearing. Once the aura has receded, the second stage, the headache, usually follows with the pain growing more intense, reaching a peak after 1-2 hours and remaining there for several hours to days before dissipating. The pain may be felt as either a constant pressure, or as a throbbing, hammering effect that is incapacitating. Many other symptoms are reported, a short list of which include nausea, vomiting, pallor, fluid

retention, hypersensitivity to external stimuli as well as flu-like symptoms. Localization of the pain has been described as often unilateral at onset, becoming more generalized as time passes. Although a headache may most commonly be experienced on one particular side of the head, persons experiencing unilateral headache also report that the headache switches sides either within or between headache episodes. Complicated migraine has been subclassified as migraine with prolonged aura, and refers to those events in which the symptoms of the aura are of a prolonged duration.

Migraine without aura (common migraine) is diagnosed when the attacks occur periodically at irregular intervals and consist of a unilateral or bilateral throbbing head pain that develops rapidly and may be accompanied by nausea, vomiting, and pallor but is not accompanied by definite premonitory signs. There are reports that claim to recognise other types of premonitory signals such as mood alterations and food cravings. With respect to the localization of the headache, it is less often unilateral than is migraine with aura.

Cluster Headache

Although cluster headache was originally classified as a vascular headache of the migraine type (Ad Hoc Committee, 1962), under the International Headache Society

classification, it has received a separate classification since it is now believed that the underlying pathophysiology is different (Raskin, 1989). These unilateral headaches occur in bouts of several attacks "clustered" during a 24 hour period (often awaking the person during the night) and while this may happen for several days running, there are long intervals in which the person is asymptomatic. The head pain is extremely intense, often described as excruciating, having boring, piercing, screwing or tearing qualities (Couch, 1982). The pain is short in duration and is generally accompanied by autonomic symptoms such as flushing, sweating, rhinorrhea and ptosis of the eye and tearing in the eye of the affected side (Spierings, 1980). Unlike migraine, cluster headaches are more frequently a male phenomena than a female. Cluster headache is much more well defined in terms of localization with the pain described as being felt in, behind and above the eye. The incidence of reported location is "orbital, 60 - 89.5 per cent, frontal or temporal, 20 - 72.4 per cent, and facial including teeth, 12 - 30 per cent" (Kudrow, 1980, p. 29). Ekblom & Kugelberg (1968) found that pain was referred from the eye and either up over the forehead and /or temple or down to the upper jaw. They concluded that the difference in the patterns of referred pain could be attributed to lesions in different sections of the carotid artery;

(specifically, the external carotid for the upward referral and the internal carotid for the downward referral).

Rationale for the Study

The underlying mechanisms of headache pain remain obscure and controversial. The key to discovering whether the location of headache pain is an important parameter in understanding either the mechanism of the headache or the diagnosis lies in providing the patient with a tool on which they can accurately describe the location of the pain.

Detailed documentation of headache location on two-dimensional representations has been outlined in the early experimental neurological and neurosurgical literature (Fay, 1939; Penfield & Norcross, 1936; Putnam, 1937; Ray & Wolff, 1940). This has been succinctly summarized by Dalessio (1980). Ray & Wolff's paper was a landmark. They made very detailed observations of the sensitivity to pain of the internal and external structures of the normal cranium on selected patients undergoing cranial surgery with local anaesthesia. The observations included the site and kind of stimulation and the location and nature of the pain that resulted. For the most part, these investigations have not been replicated although their results are still held to be true.

What was considered striking about the research done by Ray & Wolff, was that the head pain produced by intracranial

arterial stimulation and referred to the surface of the head was reproducible and characteristic of the locale where the stimulus originated. Arterial stimulation of two different points that were three to four centimetres apart referred pain that localized at different sites. Simultaneous stimulation of both points produced a pain that was referred over a larger area than if only one site was stimulated. Thus, location of headache pain appeared to be lawfully related to the underlying structure and its disturbance. If damage to pain sensitive structures in the head (either microscopic or macroscopic) follows recognizable and consistent patterns of referral then confirmation of this conjecture requires a detailed study of headache location. However, the usefulness of projecting headache pain onto a two dimensional plane when it is experienced in a three dimensional reality may be lost. An analogy proposed by Frankl (1969) easily demonstrates this. If a cylinder, (see Figure 1.), is projected out of its own three dimensional base onto a two dimensional base, one outcome is a circle, while another outcome of this projection is a rectangle. Neither outcomes show the real identity of the object. If the identity is lost or distorted, how then can the significance of the information be determined?

Figure 1. Frankl's analogy.

The same argument may be made for headache pain. One of the objectives of this research was to overcome the distortion that is obtained when the three dimensional nature of headache is projected onto a two dimensional plane. This current research arises from the suggestion by Campbell et al (1987) that an "an established relationship between extent and location of pain with specific symptoms" has the potential for identifying specific neural and/or vascular involvement as originally suggested by the tissue stimulation studies performed by Ray and Wolff in the 1940's. This appears to have been the first exploratory attempt of this nature.

Although verbal reports have often been suspect as data, nevertheless, verbal reports provide the basic data in many experimental paradigms: subjects make judgments and say "yes" or "no" when possible alternatives are suggested to them. The actual performance measure used (whether latency or number of correct responses) is derived from this verbal report, and the validity of the performance measure is actually dependent on the reliability of the verbal report. However, Ericsson & Simon (1984) suggest that accepting verbal reports as data is not a matter of faith but is an empirical issue of validation. The most important guideline in using verbal reports as data is to "specify

when, where, and under what kinds of instructions informative verbal reports can be obtained from subjects."

In one sense, pain drawings are a visual, verbal patient report. This research has undertaken to describe the "when, where and under what kinds of instructions" patient report of headache location in three dimensional space can be reliably obtained.

If individuals can reliably draw their location of head pain in three dimensions, it follows that drawings of pain location from which a volume can be derived might be an effective quantitative assessment tool. Therefore, concurrent validity with other methods of pain measurement (McDowell & Newell, 1987, p. 29) might corroborate the validity of pain drawings .

Following that train of thought, one such consideration would be to examine whether the volume measurement might be related to other quantitative measures of pain - for instance, pain intensity. Are large volumes of pain associated with high intensities? However, as suggested by Campbell, Brisebois & Hughes (1987), pain volume alone may not provide the best overall quantitative measure since low intensity pain may occupy a larger spatial distribution than high intensity pain . Intuitively, both volume and intensity are more related to the sensory qualities of pain than to the affective. Therefore, one might expect that a

combination of a volume score and an intensity score might give a more reasonable correlation with a test that includes a sensory component (such as the McGill Pain Questionnaire) than with scales that measure psychological/ affective distress (for example, the State-Trait Anxiety Inventory or the Brief Symptom Inventory).

On the other hand, one might postulate that intense headache pain would lead to a significant amount of affective distress and this might impact on how the subject perceives the space that the headache occupies. Toomey, Gover & Jones (1983) hypothesized that some psychological disturbance would be more evident in patients who report multiple pain sites (increased spatial distribution). Some support for this hypothesis was found in that the Illness Behaviour Questionnaire showed significant differences in affective disturbance for the group that reported a high number of pain sites. Although the relationship between a high number of pain sites and area was not emphasized, this can be inferred. In the same manner, volume, as a measure of spatial distribution, might therefore be a useful measure in predicting psychological disturbance. Ginzberg, Merskey & Lau (1988) examined this concept of spatial distribution and its relationship to the psychological state. Although they found limited correlation between percentage of body surface area and psychological distress as measured by the

General Health Questionnaire, they suggested that the extent of body involvement might be more related to a psychiatric study sample than the general pain population.

As stated previously (p. 20), no studies in head pain have been done to indicate whether increased spatial distribution is related to or predictive of psychological distress. Psychological distress has, however, certainly been generally implicated in headache (Blanchard, Kirsch, Appelbaum & Jaccard, 1989). This study sought to explore whether three dimensional headache pain drawings, as represented by the volume measurement, were influenced by the psychological state.

For ethical and practical reasons, exploratory analyses should be done with subjects who are diagnosed with the more common headache syndromes that are benign rather than headache syndromes associated with organic disease. Although the incidence of headache in the general population is high, organic disease is a causal factor in very few cases (Spierings, 1988). Documenting patterns of pain in patients with brain tumour, cerebral aneurysm or arteriovenous malformation would require extensive, prolonged efforts as the likelihood of finding patients with discrete disease in similar locations is small.

In reviewing the common headache syndromes, it is evident by several lines of reasoning that the diagnostic category of choice for this study is cluster headache.

In terms of location, cluster headache is most consistently defined in the literature as strictly unilateral, orbital, supra-orbital or temporal. On the other hand, unilaterality in migraine is not sufficient or necessary to delineate the diagnostic classification. Migraine patients describe many locations of headache and therefore use of this group would introduce a tremendous amount of variance into the data set and would therefore require a very large sample size.

Second, due to sex differences in spatial ability, a choice of cluster headache yields the highest proportion of a single sex. The male to female ratio is generally 6.5:1 for cluster headache whereas the female to male ratio ranges from 4:1 to 1.13:1 for migraine headache (Heyck, 1981, p. 35, 115).

Third, there is a theoretical reason for choosing cluster headache over migraine. An anatomical basis for migraine has not been proposed (Trupp, 1976) and migraine mechanisms are generally related to vasoactive or neurogenic dysfunction. Anatomical foci have been proposed for cluster headache. Anatomical foci that might account for the patterns of pain referral are external and internal carotid

artery lesions (Ekblom & Kugelberg, 1968) or the carotid body (Kudrow, 1983). Hardebo & Elner (1987) argued that the nerves and vessels in the pterygopalatine fossa could be responsible for the symptomology. More recently, an anatomical focus for the pathophysiology has been proposed (Moskowitz, 1988) to exist in the superior pericarotid cavernous sinus plexus. Due to the convergence of the complex innervation of the trigeminal system, a lesion in this region could explain the symptomology associated with cluster headache. This study is relevant to this question in that there is a need to develop non-invasive strategies that will help to differentiate the patterns of pain that exist in cluster headache. Three-dimensional descriptions of pain patterns associated with cluster headache (either alone or in conjunction with verbal description) may help to differentiate between true cluster headache and the cluster-like head pain that has been reported caused by cervical meningioma (Kuritzky, 1984), intracranial tumour (Narbonna, D'Amico,, DiMaria, Arena, & Longo, 1991), arteriovenous malformation (Gawel, Willinsky, & Krajewski, 1989; Mani & Deeter, 1981), impacted wisdom teeth (Romoli & Cudia, 1988), internal carotid artery dissection (Mohri, Sundt, & Houser, 1979) and head injury (Khurana, 1990; Reik, 1987).

Due to the exploratory nature of this research, formal hypotheses were not formed, nevertheless, three objectives were laid out. In summary, the primary objective of this study was to evaluate the reliability of the report of three dimensional drawings of headache location and to examine the validity of utilizing the volume measurement ascribed by the headache drawings as a quantitative measure of pain. A second objective was to explore what factors (pain scores, psychological state, memory, spatial ability) might influence the headache drawings or might predict psychological dysfunction. Lastly, further analyses were to be done as indicated by the data obtained.

Method

Subjects

Subjects were recruited from a patient registry list of cluster headache patients at the Headache Research Foundation associated with the John R. Graham Headache Centre, Faulkner Hospital, Boston, MA. One hundred and thirty three letters of introduction (see Appendix 1) were sent out to these individuals. A followup structured phonecall (see Appendix 2) was made to determine whether the individual fulfilled the inclusion/ exclusion criteria listed in Table 1.

Materials

Hardware/Software

An anatomic model of the human half head was purchased from The Anatomical Products catalog. This model of the head outlines major blood vessels, musculature and intracranial structures. It was used to provide an anatomically accurate head model. After providing for a scalp effect with Play-Doh, this model of the head was digitized using a Brown and Sharpe co-ordinate measuring machine. CADKEY 3.51 software allowed accurate transfer of data into a X,Y,Z coordinate space and generated the 3-D images of the head on a colour graphics monitor. These digitized images were stored in a CADKEY.PRT file and

mirrored to create the total pattern for the construction of the acrylic head model.

Using this digitized pattern, Santin Engineering of Boston produced a clear acrylic replica of the anatomic head model. A photograph of this model is shown in Figure 2. It was a whole head model which consisted of three-eighths inch horizontal plates that were stacked, shaped and formed. Since the head was constructed in these layers of acrylic, each plate could be removed and this enabled the subject to illustrate on each consecutive layer, the spatial dimensions of their headache.

A DELL System 200 computer with 640k RAM, with a 20 megabyte hard disk and a VGA Colour graphics monitor was connected via an RS232 cable to the Perceptor which is a flexible, interactive, 3-D digitizer, digitized both the model head and the pain drawings by transmitting the x,y,z coordinates of a series of points. It then created an accurate representation of the object in a digitized file.

Table 1

Inclusion/exclusion criteria.

Inclusion Criteria

1. Age: 20-60 years
2. Sex: Male
3. Able to provide informed consent.
4. Self-reported fluency in the English language
5. Diagnosis of Cluster Headache as defined by the International Headache Society, 1988.

Exclusion Criteria

1. Persons unable to complete the task of defining their head pain in three dimensions. (Failure rate and reason were to be documented.)
2. Persons with a current significant psychiatric diagnosis that, in the investigator's opinion, might compromise the ability to understand or comply with the study requirements.
3. Self-reported (non-medical) use of hallucinogens and/or psychoactive substances during cluster headache episodes.

Figure 2. Photograph of acrylic head.

The CADKEY software package is a PC-based 2-D and 3-D computer aided design tool that offers "true" three dimensional design capabilities with x,y, and z coordinate data. With its Solid Synthesis technique, it enables visualization of solid representations (for example, location of pain in the head). The program also calculates the mass properties of volume and centroid. It was the centroid that was used as the focal point of each pain region described by the patient. The x,y,z coordinates of this focal point were used as the location measure for each session.

Self-Report Scales

From the review of the literature, a number of reliable measures are noted to assess the headache experience both quantitatively and qualitatively. The "how much does it hurt" question is usually approached through verbal rating or visual analog scales. For this research, the VAS was chosen over the verbal rating scale because of its sensitivity to changes in intensity and its reliability in test-retest experiments. The "how does it hurt" attempts to also answer the "how much" question by ranking qualitative descriptors to give an overall pain score. The McGill Pain Questionnaire was selected because of its extensive usage in assessment of pain conditions and because it has been generally accepted for its reliability and validity.

A Headache Record was developed to assist the subject in recording their headache location and symptomology (see Appendix 3). It included a visual analog scale (VAS) as well as the descriptor word list of the McGill Pain Questionnaire (MPQ).

The VAS was a horizontal line scale of 10 centimetres length, with one endpoint marked as "No pain" and the opposite endpoint marked as "Worst possible pain". The VAS has been found to be reliable in test-retest experiments with correlation coefficients ranging from .95 - .97 (Revill, Robinson, Rosen & Hogg, 1976).

The MPQ word list of pain descriptors was employed as a self-report measure. The total of 20 word groupings or subcategories in the MPQ reflect the sensory dimension (Groups 1 - 10 and 17 - 20), the affective dimension (Groups 11 - 15) and the evaluative dimension (Group 16). The words in each subcategory are ranked as to their intensity. Individuals were requested to choose all words that represented their pain. It was pointed out that it was not necessary to choose a word from each subcategory or word grouping if none of the words were applicable. Two measures were obtained from the MPQ. The Pain Rating Index (PRI) was based on the rank values of the word selected in each subcategory and then these values were summed across the sensory, affective and evaluative dimensions or categories

to obtain a total PRI score (PRI-T). The Number of Words Chosen (NWC) was the sum of the words chosen over the 20 descriptive subcategories. The MPQ was scored according to a method recommended by Kremer, Atkinson & Ignelzi (1982). (See discussion, p.88.)

The State-Trait Anxiety Inventory (STAI) was designed to evaluate anxiety in a non-psychiatric population (Spielberger, 1983). It is a highly regarded instrument which contains two scales, each having twenty items. The test manual documents many studies of criterion and construct validity. Chronbach's alpha ranged between .83 and .92. Test-retest reliability was .86 for the trait dimension and was lower for the state dimension with a sex difference (.54 for males and .27 for females). Both the State and Trait inventories were administered and scored as recommended by Spielberger (1983).

The Brief Symptom Inventory (BSI), is a 53 item, standardized self-report measure of general psychological distress and has nine subscales: somatization, obsessive-compulsiveness, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation and psychoticism. Reliability and validity studies have provided evidence for its psychometric integrity. Internal consistency studies revealed alpha coefficients which range from .71 to .85 for the 9 subscales. Test-retest

reliability ranged from between .80 and .90 for the summary scales (Derogatis, 1975). The Global Severity Index "provides the most sensitive single indicator of the respondent's distress level" and it was this measure that was selected for use in the statistical analysis.

The Space Relations section of the Differential Aptitudes Test (DAT), is a 60 item test of an individual's ability to deal with concrete objects through visualization. It demands that an individual be able to mentally transform figures from two dimensional representations to three dimensional. Estimates for reliability range from .80 to over .90. Normative information is available for males and females (Hambleton, 1985). It was administered and scored as directed by the manual.

Procedure

After contact by telephone/or after a clinic visit, prospective eligible participants were asked to volunteer and to book a screening interview at their convenience.

Session 1 - Screening Interview and Admission to the Study

Information about the research project and an opportunity to ask any questions was given. A written informed consent was then completed (see Appendix 7).

Subjects were assigned a Study Number by which their data would be identified. Demographic information and relevant medical and headache information were obtained at this time from the patient. The Headache Record, the State-Trait Anxiety Inventory, the Brief Symptom Inventory and the Space Relations Test of the Differential Aptitudes Test were administered according to the directions given (see Appendices for sample tests). On the Headache Record, which included the MPQ word descriptors, the subjects were asked to recall and to describe a "typical" cluster headache. The order in which the tests were administered was determined by having the subject consecutively pick pieces of paper on which each respective test had been written. The investigator had access to the patient's medical record and this was acknowledged in the informed consent. After completing the written tests, subjects were introduced to the drawing task with the following instruction set:

Please describe on this model of a head where it is that you feel the headache associated with your "typical" or "usual" cluster headache. As you can see the head is cut in horizontal slices. Please start at the neck region and work your way up to the top of the head. If you do not experience any pain in the region defined by the horizontal slice, please do not place any marks on that slice. Describe the areas where you do experience pain by drawing them with a solid line. First, using a blue marking pen, please describe the areas on each horizontal slice, where you first notice actual pain or discomfort in the head. Then, using a red marking pen, please describe the areas on each horizontal slice, where you have pain in the head when your headache is most intense.

Session 2 - Re-test Situation

A second session, scheduled within 5-10 days of the initial screening visit, repeated the outline of Session 1 with the exception of the administration of the Brief Symptom Inventory and the Spatial Relations test.

Computerized Pain Drawings

Using the Perceptor, the areas marked by each subject for both headache onset and headache peak were digitized. Using the solid synthesis program of CADKEY, volume space representations were made and the mass properties (volume, centre point of gravity) of the described space for headache onset and headache peak were obtained. These volume patterns were saved as CADKEY.PTN files and were integrated with the digitized image or pattern file of the model head. These integrated images on the computer screen were then photographed from a distance of 6 feet with a Pentax SF1 camera with zoom lens.

Data Analysis

All data analysis utilized the Statistical Package for the Social Sciences, Personal Computer (SPSS/PC) Version 3.0. The data were first analyzed to determine whether they met the assumptions underlying the statistical tests to be used. Appropriate data transformations were made when indicated.

The demographic and descriptive data as well as the data produced by the dependent variables are presented by the appropriate descriptive statistics, measures of central tendency, frequency and proportions.

The primary objective of this study was to assess the reliability of three dimensional pain drawings in a sample

of cluster headache patients. To do this, a "typical" cluster headache was assessed at two separate time-points and the correlation between these dependent measures was obtained.

To investigate the validity of utilizing the volume measurement associated with a three dimensional pain drawing as an alternative pain measurement instrument, correlational analyses individually examined volume as a measure of pain with other standardized instruments such as the visual analog intensity score and the percentage score of the MPQ. The volume measurement multiplied by the VAS intensity score was then examined as a function of the percentage score of the MPQ.

Other exploratory regression analyses sought to determine if overall pain scores, psychological state (as measured by the STAI & BSI) or inherent spatial ability influenced the volume measure obtained from the pain drawings.

In light of finding two distinct site locations of cluster headache (periorbital versus temporal), a cluster and discriminant analysis explored the relationships of the MPQ descriptors with site of headache.

Results

Following ethical review and approval at both Carleton University and the Faulkner Hospital in Boston, an initial mailing was made to one hundred and thirty three male patients on the cluster headache registers. Forty-five patients were then personally contacted by phone. Of these, nine did not meet the inclusion/exclusion criteria, sixteen refused participation due to the following reasons: distance away from centre ($N = 9$), "too busy" ($N = 3$) or another reason was given ($N = 4$). The remaining patients ($N = 88$) were unable to be reached, either due to changes in address or time constraints with either no answer obtained or messages not returned. Twenty patients enrolled and completed the required tests. Thus, the response rate was 56% (twenty from a possible thirty-six patients) since nine did not meet the inclusion/exclusion criteria and the remaining eighty-eight were unable to be contacted. No patient was unable to complete the task of drawing the location of their head pain in three dimensional space and no patient admitted to the non-medical use of hallucinogens or psychotropic agents during cluster headache episodes. Only one subject (Subject # 2) reported one cluster headache between test - retest sessions and this subject was given explicit instructions to draw his "typical" headache, not the most recent one.

Demographic data are presented in Table 2 and headache demographics are presented in Table 3. Normal distributions were obtained on the following demographic variables: age, number of years diagnosed as cluster headache and number of months since last cluster headache. Although educational level appears well distributed, personal incomes are skewed toward the higher income brackets. This may be attributed to the fact that the Boston, Massachusetts area is one of the more expensive areas in the USA to live and work and salaries are generally correspondent. It may also be attributed to the base from which we selected our sample. The John R. Graham Headache Centre, the Patient Care Division of the Headache Research Foundation is a private clinic and most patients that would have access to this referral centre would have private insurance coverage. While some would be covered under the state's welfare program -- Medicaid, this system, in effect, eliminates a substantial number of people who do not have access to the system because of a lack of funds to purchase either health insurance or to pay for medical care as needed.

For ease of reference, the acronyms used in the statistical analysis are presented in Table 4. The scores from the VAS, MPQ, STAI, BSI and Space Relations test are outlined in Table 5.

Table 2

Demographic data on 20 cluster headache subjects.

	N	Mean	Range
Age (years)	20	39.9 + 9.8	28 -58
Marital status			
-married	18		
-single	2		
Ethnic status			
-caucasian	19		
-afro-american	1		
Education			
-less than high school	1		
-high school graduate	5		
-college/some university	5		
-university graduate	6		
-post graduate	3		
Employment			
-employed	18		
-temporarily unemployed	1		
-retired	1		
Personal Income			
-less than 10K	1		
-10-20K	2		
-21-30K	1		
-31-40K	4		
-41-50K	5		
-over 50K	7		

Table 3

Headache demographics.

	N	Mean	Range
Years diagnosed as cluster headache	20	15.7 + 9.2	3 - 38
Months since last cluster headache	20	8.5 + 6.0	0 - 21
Family history			
-no	18		
-yes	2		
Location			
-one side only	15		
-one side, may alternate	5		
Usual hemisphere			
-left side	13		
-right side	7		
Frequency of headache (number of times/day)	20	1.9 + 1.5	0.5 - 6.5
Mode of onset			
-fast (< 5 minutes)	18		
-slow (> 5 minutes)	2		
Intensity			
-severe	19		
-moderate	1		

Table 4

Acronyms.

Test/Score Used in Statistical Analysis	Acronym
Session One - Headache Onset	T1O
Session One - Headache Peak Intensity	T1P
Session Two - Headache Onset	T2O
Session Two - Headache Peak Intensity	T2P
Visual Analogue Scale	VAS
McGill Pain Questionnaire	MPQ
Pain Rating Index-Sensory	PRI-S
Pain Rating Index-Affective	PRI-A
Pain Rating Index-Evaluative	PRI-E
Pain Rating Index-Total	PRI-T
Number of Words Chosen	NWC
State-Trait Anxiety Inventory	STAI
State	STAIS
Trait	STAIT
Brief Symptom Inventory	BSI
Global Severity Index	GSI
Differential Aptitude Test	DAT
Space Relations	SPABIL

Table 5

Scores on administered tests, Session One, onset and peak.

Test Score	N	Mean	Range
VAS (raw score)	20		
onset		29.5 + 22.1	3 - 83
peak		97.0 + 6.0	74 - 100
MPQ (raw score)	20		
PRI-T onset		.25 + .19	.04 - .86
PRI-T peak		.55 + .17	.22 - .86
NWC onset		8.1 + 4.3	2 - 17
NWC peak		13.0 + 3.5	7 - 21
STAIS (percentile)	20	38.2 + 21.1	6 - 92
STAIT (percentile)	20	49.0 + 25.0	11 - 95
BSI (percentile)	20	69.7 + 25.1	11 - 100
SPABIL (percentile)	20	53.1 + 24.0	10 - 97

In order to ensure that the data met the assumptions underlying the analyses conducted in this study, the data were examined for normality, linearity, homoscedasticity and multicollinearity when appropriate for the respective analysis. In the light that much of this analysis was based on correlation, particular attention was given to ensure that the data were normally distributed since skewness will cause instability in the correlation coefficients (Tabachnick & Fidell, p. 67). There were no missing data.

While the VAS was not significantly skewed at onset, it was significantly negatively skewed at headache peak because subjects consistently indicated high intensities of pain at headache peak. In part, this may illustrate a ceiling effect due to the anchor of "worst possible pain". Transformations did not successfully normalize this distribution.

Some of the MPQ scores were also significantly skewed - and square root transformations were used to reduce the skewness in those scores. Square root transformations were chosen over logarithmic transformation since some of the scores on the MPQ were zero - particularly at headache onset. While the evaluative component of the MPQ was not significantly skewed at headache onset, 75% of the subjects scored the evaluative component as "unbearable" thus giving the highest possible score for that subcategory. Neither a logarithmic or square root transformation was able to reduce

the negative skew associated with this variable. The MPQ-PRIT score was significantly positively skewed at headache onset and was subjected to a square root transformation to normalize the sample distribution. However, at headache peak, the PRIT score was not significantly skewed and therefore no transformation was needed. The NWC variable was not significantly skewed at either headache onset or peak.

As noted above, the VAS and the evaluative component of the MPQ were significantly negatively skewed at headache peak intensity and no transformation was able to correct for this. Tabachnick & Fidell (1983, p. 81) state that "When heteroscedasticity is present, the relationship between the variables may be lawful, but it is not captured totally by the correlation coefficient. An analysis based on correlation will underestimate the extent of relationship between variables." However, in examining the difference between the correlations of untransformed versus transformed variables (Table 6), it appears that the correlations based on untransformed variables (for example, the volume measure) have consistently overestimated the degree of relationship rather than underestimated it. The statement by Tabachnick & Fidell should be qualified in that overestimations or underestimations are dependent not only on the direction of the skew but also on whether one or both variables are

skewed. Nevertheless, the test-retest correlations between Session One and Session Two remain highly significant for all measures.

The visual analog scale scores were significantly correlated with the MPQ-PRIT score ($r = .72$, $p = .001$) indicating some redundancy between these two variables. Therefore, it would be repetitive to use more than one measure in the regression analyses (Pedhazur, p. 242) as this would lead to a reduction in the magnitude of the Beta weights associated with each predictor variable. Since the MPQ-PRIT score was able to be transformed for the headache onset score and did not require transformation for the peak intensity score, this variable was selected over the VAS for use in the multiple regression analyses.

Volume measurements at both headache onset and headache peak were positively skewed. These were subjected to natural logarithmic transformations. The distributions of the percentile scores for the psychological tests (STAI & BSI) and the scores of the Space Relations test were not significantly skewed. Several transformed indices were significantly correlated implying that some measures contained some redundancy (see Tables 6 & 7). The STAI-Trait measures the "relatively stable individual differences in anxiety-proneness" and as such represent a personality characteristic (Spielberger, 1983). The State component of

the STAI is most commonly used to assess level of anxiety at an immediate moment. The BSI-GSI measures a global level of psychological distress on a variety of subscales including anxiety but not specific to anxiety. It addresses a time period of one week previous to test administration. As suggested by the study on dental pain (Kent, 1989), where high levels of anxiety contributed to overestimation in remembered unpleasantness, it could be argued that either state or trait anxiety might contribute to overestimations in the size of the spatial distribution represented by the volume variable. For statistical analyses, the more stable trait characteristic was utilized - recognizing that persons with high trait anxiety are more likely to exhibit high state anxiety more frequently and with higher scores than subjects with a low trait anxiety.

Table 6

Correlations between selected indices at headache onset.

	VAS	MPQ PRIT	MPQ NWC	AREA	VOL	STAIS	STAIT	BSI GSI	SPABIL
VAS	--								
MPQ PRIT	.69**	-							
MPQ NWC	.60*	.92**	--						
AREA	.28	.39	.46	--					
VOL	.34	.50	.56*	.93**	--				
STAIS	.10	.08	.17	.22	.16	--			
STAIT	.23	.34	.27	.39	.42	.61*	--		
BSI GSI	.20	.20	.19	.19	.15	.57*	.62*	--	
SPABIL	-.22	-.27	-.22	.16	.18	.07	-.03	.18	--

N of cases: 20 1 - tailed significance: * - .01 ** - .001

Table 7

Correlations between selected indices at headache peak.

	VAS	MPQ PRIT	MPQ NWC	AREA	VOL	STAIS	STAIT	BSI GSI	SPABIL
VAS	—								
MPQ PRIT	.31	—							
MPQ NWC	.16	.85**	—						
AREA	.22	.31	.25	—					
VOL	.24	.29	.23	.98**	—				
STAIS	-.35	.41	.18	.20	.17	—			
STAIT	-.27	.19	.04	.09	.08	.61*	—		
BSI	-.11	.20	.04	-.18	-.21	.57*	.62*	—	
SPABIL	.36	.25	.09	.07	.13	.07	-.03	.18	—

N of cases: 20 1 - tailed significance: * - .01 ** - .001

Reliability and Validity Data

Pearson product-moment correlations were used to calculate the correlation between the values obtained at Session One and at the re-test at Session Two for the untransformed variables of VAS, MPQ-PRIT and MPQ-NWC as well as for volume, area and the centroids of the three dimensional pain drawings. These correlations, as well as the correlations for the transformed variables are presented in Table 8 for the headache at both onset and at peak intensity. Although these correlations appear high, whether transformed or not, they are consistent with the raw data and with the pictorial representations. The pictorial representations for each subject are presented in Appendix 8. Effectively, these are the 3-D pain drawings of each subject for their "typical" cluster headache at both onset and at peak intensity as drawn at Session One and at the retest at Session Two. By visual inspection alone, one can see that subjects are remarkably consistent in reporting the three dimensional nature of their "typical" cluster headache.

In the examination of the validity of utilizing the volume measurement as an alternative measure of pain, the transformed volume measure was not significantly correlated at headache onset or peak intensity with the respective VAS or MPQ-PRIT scores (see Tables 6 & 7) or, as a side note,

Table 8

Pearson product moment correlations between Sessions One and Two.

	Onset	Peak
Visual Analog Scale	0.86**	0.87**
MPQ		
PRI-T	0.87**	0.90**
Square Root transformed	0.85**	N/A
NWC	0.77**	0.84**
Volume	0.95**	0.98**
LNVOL	0.88**	0.95**
Area	0.97**	0.96**
LAREA	0.96**	0.95**
Centroid		
x coordinate	0.99**	0.99**
y coordinate	0.91**	0.92**
z coordinate	0.94**	0.76**
xyz coordinates	0.85	0.69

N of cases: 20

1 - tailed significance: * - .01 ** - .001

with any of the component scores of the MPQ (sensory, affective or evaluative). Furthermore, the proposal that the volume (after log transformation) multiplied by the VAS score might best correlate with the MPQ-PRIT (see page 50) was not supported. Even though the maximum correlation obtainable could not be expected to be above .71, a correlation of .43 at onset and .29 at peak did not approach significance. (The maximum correlation obtainable would be the product of the square roots of the reliability for the volume multiplied by the reliability for the intensity scale. Given that the reliability coefficient for visual analog scales ranges from .95 - .97 and assuming a test-retest reliability for volume of .75, this would give a maximum correlation of approximately .71.)

Neither the MPQ-PRIT measure nor volume correlated with scores from the psychological measures (STAI, BSI) or the Space Relations test of the DAT.

Exploratory Data

One of the objectives of this research (see p. 66) was to investigate whether overall pain scores, psychological state or spatial ability influenced the volume measure obtained from the pain drawing. Due to the significant correlations between the STAI and the global severity index of the BSI (BSI-GSI), the BSI was not utilized in the analysis. As well, it was felt that the more stable Trait

anxiety measure would more accurately reflect the role of overall or underlying psychological distress than would the State measure which measures anxiety at that moment in time. A regression analysis using STAI-Trait, the transformed MPQ-PRIT score as well as the Spatial Relation score to predict the logarithmic transformed volume variable revealed that a reasonable amount of variance was explained by the model [$F(3,16) = 3.85$, $R^2 = .42$, $\text{Adj } R^2 = .31$, $p = .03$] with only the MPQ-PRIT contributing a significant amount of the variance at headache onset with a part correlation of .45, $p = .03$. At headache peak, the equation was not a significant predictor [$F(3,16) = .52$, $R^2 = .08$, $\text{Adj } R^2 = -.08$, $p = .67$].

No regression analysis of a linear combination of spatial ability, volume and MPQ-PRIT pain score was significant in predicting any of the psychological measures (STAIT, STAIS, BSI-GSI).

In examining the MPQ-PRIT score to determine what was driving that score - a regression of the sensory, affective and evaluative components predicting the overall score revealed that all the components contributed significantly, but the sensory component [$F(3,16) = 1087.6$, $R^2 = .99$, $\text{Adj } R^2 = .99$, $p = .000$] was the driving factor at headache onset with a Beta of .76 and a part correlation of .45 as opposed to the affective and evaluative Beta weights of .20

and .10 and part correlations of .13 and .08 respectively. At headache peak, [$F(3,16) = 1468$, $R^2 = 1.0$, Adj $R^2 = 1.0$, $p = .0000$], the sensory component again had the highest Beta (.78) and part correlation (.62) as compared to the affective (Beta = .27, part correlation = .22) or the evaluative (Beta = .08, part correlation = .07).

To gain some insight into the three dimensional relationship between the centroid points of the twenty subjects, a CADKEY file containing the centroids was integrated with the pattern file of the model head. This is illustrated by the photograph of the centroid at peak intensity as shown in Figure 3. At both onset and peak intensity, two primary regions of headache location were identified by a visual clustering of the centroids - one was periorbital and the other was temporal. This has been illustrated by a lateral view of the centroids (see Figure 4), again at peak intensity. Temporal headaches spanned a much wider spatial distribution than did orbital headaches. Mean headache volumes at onset and at peak intensity are listed in Table 9. At onset, one patient identified their primary focus for pain as in the neck region thus $N = 19$ for this division between temporal and periorbital.

To examine the differences between periorbital and temporal headaches, one way ANOVAS were run and no

significant differences in age, number of years diagnosed with cluster headache, frequency or duration of headache were found. Nor were significant differences found in VAS, MPQ-PRIT, MPQ-NWC scores at headache onset or peak, or on the STAI, BSI or Space Relations test scores. However, while volume at headache onset was not significantly different between orbital and temporal headaches, volume was significantly higher for temporal headaches than for periorbital headaches at peak intensity (see Table 9). Caution must be used in interpreting this data as the numbers for the temporal headache is small ($N = 5$) and the standard deviations are large.

Figure 3. Photograph of centroids (centre points of headache location) at peak intensity.

Figure 4. Lateral view of centroids identifying two locations of headache pain - one periorbital and one temporal at peak intensity.

2 OF/DE 2

PM-1 3 1/2" x 4" PHOTOGRAPHIC MICROCOPY TARGET
NBS 1010a ANSI/ISO #2 EQUIVALENT

Table 9

Mean headache volumes (cm³) at onset and peak intensity.

	Onset	Peak
Periorbital	29.9 + 68.8	121.1 + 104.8**
Temporal	100.1 + 183.5	713.8 + 570.5**

** pooled variance, $t = -4.03$, $df = 18$, $p = .001$
(two-tailed test).

In terms of spatial distribution of headache, the most striking finding of this research was the significantly larger volumes associated with temporal headaches when compared to those associated with periorbital headaches. Keep in mind that it is perhaps confusing to talk of doing "cluster" analyses on "cluster" headache. Nevertheless, several exploratory cluster analyses were performed on the data. Since the sensory component of the MPQ drove the overall PRIT score, the MPQ sensory category variables were examined to determine how these variables clustered together in describing cluster headache and whether scores on the MPQ sensory category variables would subclassify cluster headache according to the site of the headache (periorbital versus temporal). MPQ sensory category variables are outlined in Table 10. For the cluster analyses, the MPQ was scored as suggested by Melzack (1983), using the rank order score of each variable category. For example, if the subject had checked boring and stabbing under Variable 3 - Punctate, the score for that category variable would have been a four, representing the score for the highest rank checked; if the subject had only checked the word boring, the score for the variable would have been a two.

Table 10

MPQ sensory category variables.

Variable 1 Temporal flickering pulsing throbbing beating pounding	Variable 2 Spatial jumping flashing shooting	Variable 3 Punctate pricking boring drilling stabbing
Variable 4 Incisive sharp cutting lancinating	Variable 5 Constrictive pinching pressing gnawing cramping crushing	Variable 6 Traction tugging pulling wrenching
Variable 7 Thermal hot burning scalding searing	Variable 8 Brightness tingling itchy smarting stinging	Variable 9 Dullness dull sore hurting aching heavy
Variable 10 Sensory Misc tender taut rasping splitting	Variable 11 Spatial Misc spreading radiating penetrating piercing	Variable 12 Pressure Misc tight numb drawing squeezing tearing
Variable 13 Coldness cool cold freezing		

In the cluster analyses, since the range of values on Variable 1 - Temporal is greater than the range of values on Variable 2 - Spatial (respectively, five descriptors versus three), the data were standardized to eliminate the greater weight in determining similarity that would be attributed to those variable categories that contained more descriptors (Romesberg, 1984).

Although within each MPQ variable category a rank order score was obtained, the MPQ variable categories themselves are of a nominal level of measurement. Therefore, a similarities matrix between the MPQ variable categories was constructed using the contingency coefficient. The contingency coefficient provides a measure of association between the variable categories but it does not give any information of the direction or the nature of the relationship.

The similarities matrix was turned into the dendrogram by agglomerative hierarchical clustering based on the average linkage between groups method as outlined by Norusis (1988, p. B-83). This method is one that is most widely used (Romesberg, 1984) and is appropriate because in using the average similarity between two clusters as the average of the distances between all pairs of subjects, it tends to produce less distortion in transforming the similarities between the subjects into a dendrogram. The decision rule

used to determine where to cut the dendrogram was at the widest range of the coefficient as recommended by Romesberg (1984) since this is indicative that the clusters are well separated in the attribute space.

The first analysis, based on all subjects and on all the MPQ sensory variable categories at headache onset, revealed that all the subjects clustered together with the exception of Subject # 13 (see Figure 5).

The second analysis, based on all subjects and on all the MPQ sensory variable categories at headache peak, revealed that all the subjects clustered together with the exception of Subjects # 16 and # 7 (see Figure 7).

A discriminant analysis on the groups as defined by location of headache - either periorbital or temporal supported the above conclusions and showed that the MPQ variable categories did not discriminate or predict periorbital or temporal group membership at either headache onset ($p = .39$) or headache peak ($p = .46$).

Figure 5. Dendrogram using average linkage cluster analysis showing the relationship between the subjects on the McGill Pain Questionnaire sensory variable categories at headache onset.

Figure 6. Dendrogram using average linkage cluster analysis showing the relationship between the subjects on the McGill Pain Questionnaire sensory variable categories at headache peak.

Despite there being no obvious difference in left and right sided centroids (see Figures 5 & 6), in looking at the pictorial representations (see Appendix 8), some differences between left and right sided headaches appear in the spatial distributions of the headaches. Most of the right sided headaches were periorbital and the periorbital distributions appear remarkably similar - much more so than the left sided headaches.

To further investigate, means and one-way ANOVAS were done between left and right sided headaches on a number of demographic variables (age, number of years diagnosed with cluster headache, frequency of headache occurrence during cluster, duration of headache) as well as on the dependent measures (VAS at headache onset and peak, MPQ-PRIT, MPQ-NWC scores at onset and peak, volume at headache onset and peak, STAI, BSI and Space Relations scores). No significant differences were found between left and right sided headaches on any of these variables.

Discussion

The limitations of a the small sample of male subjects with a distinctive headache type and using retrospective or recall assessments must be considered in discussing the findings of this research. Nevertheless, this research does suggest that selected patients are able to reliably report the location of their localized "typical" headache by drawing on a three dimensional head model. Overall MPQ pain scores, psychological state or inherent spatial ability did not appear to be factors that influenced the size of the headache pain drawings at peak intensity. However, at peak intensity, periorbital and temporal headaches were identified with temporal headaches having a much larger volume than did the periorbital headaches although the MPQ sensory variables were not able to differentiate between these two types of headache.

Reliability and Validity Data

The VAS test-retest reliabilities (see Table 6) are within the range of that reported in the literature. Scott & Huskisson (1976) report a correlation of .99 between vertical and horizontal scales but this is not the same as a test-retest reliability administered with an intervening time period such as in the study reported on by Revill, Robinson, Rosen & Hogg (1976). In that experiment, a remembered pain, considered to be sufficiently remote in

time (i.e. several months previous) so as to be taken as a constant stimulus, was tested at a time span of 5 minutes and 24 hours. Test-retest correlation coefficients ranged from .95 - .97.

In the present study, the Pearson parametrical, test-retest correlations of .86 and .87 for the VAS (at headache onset and peak respectively) with a testing time span of 5 - 10 days are between those found by Revill et al (1976) and those found by Linton & Gotestam (1983) who found a mean test-retest correlation of .60 for subjects asked to remember how much pain they had at the beginning of a treatment program 4 - 9 weeks previous. As noted previously, parametrical analysis is considered legitimate treatment of the VAS (McDowell & Newell, 1987, p. 16).

Although factorial analyses have generally supported the multidimensional nature of the MPQ, few studies have addressed the test-retest reliability issue. The consistency index of .75 obtained by Melzack in 1975 was done with a small number of subjects (McDowell & Newell, 1987, p. 247) and does not appear to have been repeated. The Pearson product moment correlations for MPQ-PRIT scores (.85 and .90) would appear to be consistent with the literature although one might argue that because of the rank order or categorical nature of the variable categories of the MPQ, it would be more conservative to use a

non-parametric analysis rather than Pearson product moment correlations to determine the test-retest reliability between Sessions One and Two. A post-hoc non-parametric analysis on the untransformed MPQ-PRIT variable using Kendall's tau b for ordinal measures gave a correlation coefficient of .63 for onset ($p = .0001$) and .81 for peak ($p = .0000$).

Traditionally, a subject is only allowed to pick one word per subcategory. For scoring purposes, if a subject has selected more than one word in a subcategory, the word with the highest rank score is the one used in the calculation. Due to the discrepancy between the number of subcategories in the MPQ between the sensory (14), the affective (5) and the evaluative (1) dimensions, it is difficult to compare the relative importance of each dimension in the overall scheme of things. This dilemma has produced an alternative method of scoring the MPQ. Kremer, Atkinson and Ignelzi (1982) calculated the score for each dimension by "summing the rank order intensity for each dimension and dividing that summated value by the total possible score on that dimension. This procedure yields scores that range from 0 - 1.0 and illustrates the contribution of each dimension to the overall PRIT score and, in effect, produces an ordinal ranking of the subcategories for each individual.

In assessing the reliability of the 3-D pain drawings, the reliability of the volume and the centroid associated with the 3-D headache drawing was evaluated. The correlations between Sessions One and Two for the transformed volume and area variables as well as for the centroids speak for themselves and are supported by visual inspection of the headache representations. The conclusion is that subjects are remarkably consistent in drawing the location of their "typical" cluster headache.

What, if any, is the meaning or usefulness of documenting the location of headache in three dimensional space? What factors, if any, influence subject report of headache location?

In the examination for concurrent validity of the volume measurement with other pain measurements, we had proposed that volume might be related to pain intensity (VAS) or that it might be related to the overall MPQ pain score. Although Campbell, Brisebois & Hughes (1987) found that subjects reporting small areas of pain used different pain descriptors (ie piercing vs heavy) than those reporting larger areas, they did not report any correlational studies between area and intensity. However, there is no evidence in the literature that any previous studies using pain drawings have attempted to correlate area or spatial distribution with pain intensity. The hypothesis that the

transformed volume measure multiplied by the intensity measure might best correlate with the MPQ was not supported either at headache onset ($r = .43$, NS) or headache peak ($r = .29$, NS).

Volume measurement may well have face and construct validity but simply may not be measuring the same construct as the MPQ and, perhaps intuitively, this makes sense. However, perhaps the most significant validity is ascribed by the patients themselves who appeared to derive great satisfaction from being able to describe, in detail, the location of their headache. Subjects would frequently look at their headache drawing, announce, "Yes, that's it!". It would be of interest, in future research, to ask the subjects themselves, how important it was to them to be able to communicate the information about location and extent of their headache pain. Even though these three dimensional drawings of headache location are simple pain drawings, the face validity of all pain drawings may be supported by the impressions of the artistic community as they have attempted to translate their experience with their own headache phenomena into artistic representations. This artwork (Wicklegren, 1989) has graphically depicted not only what the sensory system has perceived (visual aberrations, autonomic accompaniments) but also what is felt emotionally

(depression, fear) or what meaning they have attributed to their headache (disease, alienation, effect on lifestyle).

As discussed in the introduction, the issue of memory for pain is relevant to the issues of reliability and validity of a pain measure - whether a numerical assessment, verbal description or pain drawing. For the VAS, it is interesting to note that while Linton & Gotestam (1983) did not find that accuracy of recall declined with time within their study, the correlation coefficients show a decreasing trend as the interval between test-retest increases (See Table 11). While time may be the most plausible factor for memorial inaccuracy, the differences between these studies may suggest that different cognitive strategies are used to remember pain when using verbal scales as opposed to numerical or visual analog scales, or perhaps different biases operate when comparing a remote pain stimulus with one that has subsequently undergone treatment.

The study of memory for pain is constrained by the difficulty that it remains "a complex perceptual experience that can be quantified only indirectly" (Chapman, Casey, Dubner, Foley, Gracely & Reading, 1985) and one that can only be vicariously interpreted by words and pictures. In one sense, all reports of pain are a recall measure in that they all require a cognitive processing in order to be communicated.

Table 11

Comparison of correlations for varying test-retest intervals.

	Revill et al (1976)	Fraser (1991)	Linton & Gotestam (1983)
	24 hours	5 - 10 days	4 - 9 weeks
Correlation Coefficient	.95 - .97	.86 - .87	.60

Although introspection on cognitive processes may not always be reliable, subjects, in this study, seemed to be recalling and re-experiencing the headache - several subjects commented that they were afraid to do this study because "it might bring on a cluster headache".

Remembrances perhaps of Merskey's "mnemic traces"!

This methodology utilized a recall measure asking that subjects recall and draw the location of their "typical cluster headache". As in the experiment by Revill et al (1976), the recall of the "typical cluster headache" was considered to be sufficiently remote in time and sufficiently stable in structure so as to be taken as a constant stimulus, particularly since only two subjects experienced their last cluster episode either during or within the month previous to testing. Furthermore, in support of the concept of a "stable stimulus structure", Linton & Gotestam (1983) found that subjects were most consistent between pre-baseline estimates of pain and their remembered pain rating. This suggested to Linton & Gotestam that patients came to treatment with a clear cognitive evaluation of their pain.

The utilization of the recall measure at a point in time when the subjects were painfree, makes it somewhat difficult to relate to Bower's associative network theory or to the studies that relate mood and memory (Blaney, 1986;

Singer & Salovey, 1988) other than to note that affectively intense material is learned best and therefore assumed to be remembered best.

I propose that the distinctiveness, the vividness of a cluster headache is such that it makes it easy to remember. This concept is not only supported by Shedler & Manis (1986) but also by the autobiographical studies on memory by Brewer (1988) who reported that recall depends primarily on the uniqueness and degree of excitement associated with the situation. Cluster headache falls into what Brewer (1988) describes as part of an individual's generic personal memory that is a recollection "that seems to incorporate several repeated events" and is described typically as a "reliving" of the experience, one which often "involves visual imagery and frequently includes ... felt affect".

In an attempt to integrate cluster headache pain with a theoretical and neuropsychological theory of memory, I would also suggest that the recollection of a "typical" cluster headache is enhanced by the very task of asking about headache location. Neisser (1988) reports that generic images are often accompanied by specific images that may function as carriers of information (particularly in mental rotation experiments) but that these images also serve as an 'illustration' of that memory - presenting a specific aspect of the generic event in visual form

(p. 367). Even though memories may most often originate as sensory impressions (Mishkin & Appenzeller, 1987), Neisser's theoretical position would suggest that the sensory component (for example, in this instance, the sensory descriptors of the MPQ) of the recall measures may be more easily recalled when the sensory information is "nested" within the spatial cognitive module (p. 368) of headache location. Neisser further suggests that the spatial cognitive module may itself be the most significant vehicle of personal memory since all the features of the spatial cognitive system (nesting, hierarchical structure and ability to mentally revisit places) are also significant characteristics of autobiographical personal memory.

Exploratory Data

Studies that have utilized pain drawings (Uden & Landin, 1987; Ransford, Cairns & Mooney, 1976; Von Baeyer, Bergstrom, Brodwin & Brodwin, 1983) have primarily focused on whether "unacceptable" pain drawings were related to the psychological state - "unacceptable" meaning "pain drawings that deviated from accepted patterns of pain location and referral" (p. 19). With limited knowledge of patterns of pain location and referral, it must be questioned as to what is "acceptable". Poletti (1991) has made an able demonstration that even "acceptable" distributions of sensory innervation change.

While this research did not label drawings as acceptable or unacceptable, it did evaluate whether the psychological state might have influenced the spatial distribution or volume of the headache by examining the correlations between the volume measure and the psychological measures (STAI-S, STAI-T, BSI) obtained. Although the penalty rating study by Ransford et al (1976) suggested the hypothesis that larger spatial distributions of headache (in this case represented by the volume variable) would be indicative of excessive psychological distress, this study does not lend support to that hypothesis. Not only was there a lack of significant correlations between volume and any of the psychological measures (see Tables 6 & 7), but regression analyses of the transformed MPQ-PRIT score, the spatial relation score and the log transformed volume score in predicting any of the psychological measures were not significant at either headache onset or peak. From this research, individuals with high anxiety or with high ratings on the global psychological distress scale did not necessarily draw larger headache drawings.

However, at headache onset, a regression model including a psychological measure (STAI-T) was supported when volume was predicted from the linear combination of the Trait Anxiety score, the Spatial Ability score and the MPQ-

PRIT score. There are three points of note here. The first is that the regression model was only significant at the onset of the cluster headache but not at the peak of the headache. Therefore, one might conclude that lower overall pain scores are associated with smaller volumes of headache pain when taken in combination with spatial ability and trait anxiety. However, the question remains as to why the model was predictive at headache onset but not at headache peak - I suggest that the answer lies in the intensity of the pain that is associated with cluster headache and that it overshadows all other factors - even though, with the MPQ, a ceiling effect on the measurement scale was not noted.

The second point is that spatial ability did not appear to influence the volume distribution of the pain drawings. For an individual to draw the location of his headache in three dimensional space, it was assumed that that individual would require some ability to take the internal image of the headache location, manipulate and rotate that image and represent it on the three dimensional model. One concern was that a bias in pain drawings might be produced by those individuals who were less proficient in their spatial skills, i.e. persons with poor spatial ability might be unable to localize the headache and therefore their headache drawings might tend to be larger. Since the correlations

between spatial ability and volume were not significant and spatial ability did not contribute significantly to the regression model (i.e. individuals with low spatial ability did not necessarily overestimate or underestimate the volume occupied by their headache because of their lack of ability to manipulate "in their mind's eye" the mental representation of the headache), it is concluded that spatial ability did not, in any significant way, influence the size of the headache drawings. Interestingly, Wilf, Tyano, Munitz, & Wijsenbeek (1983) requested subjects to draw "the size of the brain". They found that drawings done by males tended to be more extreme than those done by females. How gender differences might have accounted for this finding was not postulated nevertheless, due to the controversy over gender differences in spatial ability, gender was controlled for in this study and that may have prevented a confound in the analysis.

Clinical reports (Jackson, 1974; Benton, 1969; Paterson & Wangwill, 1944) of patients suffering from significant brain lesions with specific defects in spatial visualization and organization have suggested that the right hemisphere is more important than the left in mediating spatial ability (Benton, 1982). One might therefore wonder, especially in the light of Merskey's "mnemic traces" if subjects experiencing right sided cluster headaches might demonstrate

an impaired spatial ability. However, no significant differences in spatial ability scores were found between left and right sided headaches.

The third point of note is that the MPQ-PRIT score was the only significant contributor to the regression model of the Trait Anxiety score, the Spatial Ability score and the MPQ-PRIT score in predicting volume at headache onset. As noted previously, the overall PRIT score was primarily driven by the sensory component at both headache onset and peak. Due to the significant differences in headache volume between temporal and periorbital headaches and keeping in mind the finding (p. 21) by Campbell et al (1987) of subjects utilizing different qualitative pain descriptors to describe smaller areas of pain as compared to larger areas, the sensory data was examined by means of cluster analysis. The goal of the cluster analysis was to identify whether the cluster headache group was a homogeneous group in terms of their verbal pain descriptions of the cluster headache. The underlying hypothesis to this was that if periorbital cluster headache subjects utilized the MPQ to verbally describe their headache in a different manner than did the temporal cluster headache subjects, this would theoretically imply that location of cluster headache might be significant in diagnosis. Although Jerome et al (1988) found that the MPQ differentiated between cluster headache and

migraine/muscle contraction headache on the basis of the qualitative descriptors, the research was not focused to examine subgroupings of cluster headache.

Neither the cluster nor the discriminant analyses suggested that periorbital or temporal cluster headache subjects utilized the MPQ sensory variable categories in a differential manner. However, the sample was small (total $N = 20$), - particularly for the temporal cluster headache subjects ($N = 5$) - and the sample sizes were unequal. Although the assumptions underlying a cluster analysis are broader than for a discriminant analysis, nevertheless, it would be unwise to accept this as a definitive answer. Statistically, this N is not sufficient since the number of variable categories (13) is over one-half the sample size.

The best that can be said is that the cluster and discriminant analysis would point to accepting that the sample was fairly homogeneous. In one sense, this is somewhat reassuring, especially for classification purposes, since the sample was selected by guidelines set by the International Headache Society.

In conclusion, the present study shows that patient report of the location of a "typical" cluster headache in three dimensional space is a reliable patient report of subjective experience. This reliability is compatible with both the memory model of Shedler & Manis (1986) and the

spatial cognitive module suggested by Neisser (1988) in that cluster headache is a distinctly vivid and unique headache experience. However, it is this uniqueness and the fact that, unlike other headache types, this type of headache is a male-dominated phenomenon, that suggests caution in applying these findings to the general headache population.

Due to the novel nature of this research, a number of exploratory analyses were done to look at what factors might influence the patient report of three dimensional headache location and herein lies one limitation to the research - multiple analyses were done with a sample size of twenty subjects.

Although this study was somewhat retrospective in nature, in that headache location was drawn from recall, this study is not subject to many of the limitations found in true retrospective studies (missing data, alternative methods of classification, differences in patient instruction). Nevertheless, it would have been preferable for subjects to continue in the study during a cluster episode and to draw the location of their most recent cluster headache within a short recall period. One would then be able to look at the reliability of individual report as well as the variability in headache location between the stable structure of a "typical cluster headache" and the most recent headache.

With the above limitations in mind, the following conclusions are tentatively offered and future research is necessary to confirm or to disaffirm these hypotheses.

Neither spatial ability nor the psychological state appears to influence the size of the headache drawings. Persons with low spatial ability or with high scores on the indices of psychological distress did not draw significantly larger volume drawings of headache pain location. Nor did the spatial distribution of pain (as indicated by the volume measure) predict scores on psychological tests. Future research might examine whether a somatization scale or hypochondriasis scale or, for instance, the Brief Symptom Inventory, were more predictive of larger volumes of headache.

The most striking and significant finding in this research is, I believe, that temporal cluster headaches occupy a greater volume space in the head than do those that could be classed as periorbital. Although the general knowledge of cluster headache would not suggest that this division of headache location is unexpected (note Kudrow's quoted incidence of orbital headache being 60% versus frontal and temporal headache 20 - 72% [see p.44]) the finding of the greater volume associated with the temporal headache is new information and strongly suggests that future research with an adequate sample size should focus

more definitively on what might contribute to this difference. Are symptoms different? Do subjects utilize pain descriptors differentially?

In addition, this patient report of headache location needs to be integrated with the neurophysiology and proposed neuroanatomy of headache. From the data that Ray & Wolff (1940) so rigorously collected, they formed inferences concerning the mechanisms of headache. Since the cranial vasculature far outweighed any other structure with respect to its ability to produce painful sensations, Ray & Wolff concluded that the primary mechanisms responsible for head pain lie in traction, displacement, inflammation and/or distention of the cranial vasculature. Traction and displacement are commonly quoted causes for head pain in structural organic diseases such as cerebrovascular disease and brain tumour. On the other hand, inflammation and distention (of the extracerebral vessels according to Wolff's theory) are more commonly associated with the more "benign" headache syndromes such as vascular and muscle contraction headaches. However, since not only large vessels are sensitive to pain but even the capillaries, (Landis, 1930 in Heyck, 1981, p. 54), it may well be that biochemical processes may be operative at the capillary level in the production of head pain, particularly in vascular types of headache.

Vasoactive amines such as histamine and bradykinin (Sicuteri, 1963; Theoharides, 1983), catecholamines (Anthony & Lance, 1969), and dopamine (Cangi, Fanciullacci, Pietrini, Boccuni & Sicuteri, 1985) have all been implicated. Changes in serotonin levels (MacKenzie, Edvinsson, & Scatton, 1985; Raskin, 1988; Welch, 1982) and endogenous opioids (Sicuteri, 1982; Ibid, 1985) have also been demonstrated.

With reference to this research, future research should incorporate other three dimensional methods of imaging and other neuroanatomical and neurophysiological studies. Perhaps, most promising is the work done by Goadsby, Zagami, & Lambert (1991), who have demonstrated by radioimmunoassay that a powerful dilator peptide called calcitonin related gene peptide (CRGP) which is present in trigeminal neurons may play a pivotal role in headache physiology and phenomenology. For instance, future research with radioactively labelled CRGP followed by computer assisted tomography or positron electron scanning might provide a link between subjective reports of headache location and objective evidence of biochemical dysfunction at a neuroanatomical level.

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Appendix 1

February 1990

Dear

In the last Newsletter of the Headache Research Foundation (Spring, 1989), the initial story was about a new research project that was to begin here at the John R. Graham Headache Centre (Copy enclosed). This research study is now entitled "Three Dimensional Drawings of Pain Location in Cluster Headache".

We are interested in documenting these patterns of pain for three reasons. First, because patients often express difficulty in being able to tell their primary practitioner exactly where their headache is located, a physical three dimensional model might enable them to this. Second, although we have several ways of measuring pain, no one has looked at whether the space or volume over which pain is distributed could be used as a measurement of pain. Third, this technique may contribute to our understanding of the mechanisms that cause cluster headache by differentiating the patterns of pain that are produced. The focus of this study is to determine how well people can describe their headache in three dimensional space.

We are happy to report that the funding for this project has been completed and the production of the 3-D model of the head is nearing completion. As a result, we will be contacting you in the near future to enquire about the possibility of your participating in this research project. We hope that you will be able to assist us in this endeavour and we thank you for your interest in our research and programs.

Yours sincerely,

Egilius L. H. Spierings, MD, PhD
Director

Ruth Ann Fraser, RN, BSc
Clinical Research Coordinator

Appendix 2

Structured Telephone/Personal Interview

Hello, my name is Ruth Ann Fraser. I am a nurse at the Headache Centre and I am calling to enquire whether you would be interested in participating in a research project here at the Headache Centre. What this research project aims to do is to document three dimensional patterns of pain in the head. We are interested in this for three reasons; first, because patients often experience difficulty in being able to tell a physician where it is that their headache is; second, this technique may provide us with new ways of measuring pain; and third, this technique may provide new insights into possible mechanisms of headache. Would you be interested in knowing more about this? Dr. ----- gave me your name because you have cluster headaches. Perhaps my first question should be, what type of headache or what types of headache do you experience at present. Could you describe them for me?

This research project is not a treatment program and would in no way change the medical management of your headache. If you were to participate in this project, you would need to come to the Headache Centre for a total of 4 visits. During the first visit, you will have the procedure explained to you.

Do you have any questions at this time? Would you be willing to come in for a screening interview in order to discuss this more fully?

THREE DIMENSIONAL DRAWINGS OF PAIN LOCATION IN CLUSTER HEADACHE

HEADACHE RECORD

Date of headache onset _____ (mo/day/yr)

Time of headache onset _____ am pm

NOTE: These questions all apply to the pain and the symptoms that you feel at the beginning of your headache.

Please draw and shade in the location and the extent of the pain at the beginning of your headache. Each drawing is a flat, two-dimensional representation of one view of the head. The head, of course is rounded and continuous. Thus it is possible that where pain is experienced may for some people be indicated on more than one drawing.

RIGHT

BACK

FRONT

LEFT

Head Pain Location in 3-D

McGill Pain Questionnaire

Please read through each grouping of words and check each word that best describes your headache at the onset of the headache.

☐ flickering	☐ hot	☐ fearful	☐ cool
☐ pulsing	☐ burning	☐ frightful	☐ cold
☐ throbbing	☐ scalding	☐ terrifying	☐ freezing
☐ beating	☐ searing	☐ punishing	☐ nagging
☐ pounding	☐ tingling	☐ gruelling	☐ nauseating
☐ jumping	☐ itchy	☐ cruel	☐ agonizing
☐ flashing	☐ smarting	☐ vicious	☐ dreadful
☐ shooting	☐ stinging	☐ killing	☐ torturing
☐ pricking	☐ dull	☐ wretched	
☐ boring	☐ sore	☐ blinding	
☐ drilling	☐ hurting	☐ annoying	
☐ stabbing	☐ aching	☐ troublesome	
☐ sharp	☐ heavy	☐ miserable	
☐ cutting	☐ tender	☐ intense	
☐ lancinating	☐ taut	☐ unbearable	
☐ pinching	☐ rasping	☐ spreading	
☐ pressing	☐ splitting	☐ radiating	
☐ gnawing	☐ tiring	☐ penetrating	
☐ cramping	☐ exhausting	☐ piercing	
☐ crushing	☐ sickening	☐ tight	
☐ tugging	☐ suffocating	☐ numb	
☐ pulling		☐ drawing	
☐ wrenching		☐ squeezing	
		☐ tearing	

Head Pain Location in 3-D

Please indicate by placing a mark across the line, how much pain you have at the beginning of your headache:

NO PAIN

WORST POSSIBLE PAIN

Please place a checkmark besides the symptoms that you have at the onset of your headache and a checkmark as to whether on the right (R) or left (L) or on both if that is the case.

☐ pain is on the right side of the head		
☐ pain is on the left side of the head		
☐ pain is on both sides of the head		
☐ pain is in the eye	R	L
☐ pain is above the eye	R	L
☐ pain is behind the eye	R	L
☐ pain is below the eye	R	L
☐ eyelid droops	R	L
☐ eyelid is swollen	R	L
☐ white of eye is reddened	R	L
☐ eye tears	R	L
☐ nose is stuffy	R	L
☐ nose runs	R	L
☐ sweating on forehead	R	L
☐ sweating on face	R	L
☐ pupil on one side is different than other	R > L	L > R

Head Pain Location in 3-D

NOTE: These questions all apply to the pain and the symptoms that you feel when your headache is most intense:

Please draw and shade in the location and the extent of the pain at the beginning of your headache. Each drawing is a flat, two-dimensional representation of one view of the head. The head, of course is rounded and continuous. Thus it is possible that where pain is experienced may for some people be indicated on more than one drawing.

RIGHT

BACK

FRONT

LEFT

Head Pain Location in 3-D

McGill Pain Questionnaire

Please read through each grouping of words and check each word that best describes your headache when it is most intense:

☐ flickering	☐ hot	☐ fearful	☐ cool
☐ pulsing	☐ burning	☐ frightful	☐ cold
☐ throbbing	☐ scalding	☐ terrifying	☐ freezing
☐ beating	☐ searing	☐ punishing	☐ nagging
☐ pounding	☐ tingling	☐ gruelling	☐ nauseating
☐ jumping	☐ itchy	☐ cruel	☐ agonizing
☐ flashing	☐ smarting	☐ vicious	☐ dreadful
☐ shooting	☐ stinging	☐ killing	☐ torturing
☐ pricking	☐ dull	☐ wretched	
☐ boring	☐ sore	☐ blinding	
☐ drilling	☐ hurting	☐ annoying	
☐ stabbing	☐ aching	☐ troublesome	
☐ sharp	☐ heavy	☐ miserable	
☐ cutting	☐ tender	☐ intense	
☐ lancinating	☐ taut	☐ unbearable	
☐ pinching	☐ rasping	☐ spreading	
☐ pressing	☐ splitting	☐ radiating	
☐ gnawing	☐ tiring	☐ penetrating	
☐ cramping	☐ exhausting	☐ piercing	
☐ crushing	☐ sickening	☐ tight	
☐ tugging	☐ suffocating	☐ numb	
☐ pulling		☐ drawing	
☐ wrenching		☐ squeezing	
		☐ tearing	

Head Pain Location in 3-D

Please indicate by placing a mark across the line, how much pain you have when your headache is most intense:

NO PAIN

WORST POSSIBLE PAIN

Please place a checkmark besides the symptoms that you have when your headache is at its most intense. Also check whether on the right (R) or left (L) or on both if that is the case.

☐ pain is on the right side of the head

☐ pain is on the left side of the head

☐ pain is on both sides of the head

☐ pain is in the eye R L

☐ pain is above the eye R L

☐ pain is behind the eye R L

☐ pain is below the eye R L

☐ eyelid droops R L

☐ eyelid is swollen R L

☐ white of eye is reddened R L

☐ eye tears R L

☐ nose is stuffy R L

☐ nose runs R L

☐ sweating on forehead R L

☐ sweating on face R L

☐ pupil on one side is different than other R > L__ L > R__

Head Pain Location in 3-D

NOTE: These questions all apply to the pain and the symptoms that you feel when your headache is most intense:

Please draw and shade in the location and the extent of the pain at the beginning of your headache. Each drawing is a flat, two-dimensional representation of one view of the head. The head, of course is rounded and continuous. Thus it is possible that where pain is experienced may for some people be indicated on more than one drawing.

RIGHT

BACK

FRONT

LEFT

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- Appendix 5 - Space Relations of the Differential Aptitudes Test (Form V)
by C.K. Bennett, H.G. Seashore & A.G. Wesman
- Appendix 6 - State-Trait Anxiety Inventory (STAI)
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Informed Consent

Three Dimensional Drawings of Pain Location in Cluster Headache.

You are being asked to participate in a research study that aims to document the location of cluster headache in three dimensions (3-D). This research study is not a treatment program and will not change the medical management of your headache. If you were to participate in this project, you will be requested to come to the Headache Centre a total of four visits, during which time you will draw, on a three dimensional model, the location of your headache. We are interested in documenting these patterns of pain for three reasons. First, because patients often express difficulty in being able to tell their primary practitioner exactly where their headache is located, a physical three dimensional model might enable them to this. Second, although we have several ways of measuring pain, no one has looked at whether the space or volume over which pain is distributed could be used as a measurement of pain. Third, this technique may contribute to our understanding of the mechanisms that cause cluster headache by differentiating the patterns of pain that are produced. The focus of this study is to determine how well people can describe their headache in three dimensional space.

If you agree to participate in this study, you will be asked relevant information about your headache and medical histories. The investigator will have access to your medical record.

At the first visit you will be requested to draw the location of your "typical" cluster headache. You will draw the location of this headache for when you first notice that you have a headache and for when your headache is at its most intense. In addition, you will fill in several questionnaires and one Headache Record. These questionnaires will give us information on the intensity and the qualities of your headache, how much general psychological distress you are experiencing and how well you are able to visualize objects in three dimensions. This first visit will take approximately two hours to complete.

At the second visit, which must be separated from the first by a period of 5-10 days, you will again be asked to draw the location of your headache in the same fashion as during the first visit. At this time, you will fill in two of the questionnaires (BSI and STAI) and the Headache Record for your typical headache. This visit will take approximately one hour. At this visit, you will be given copies of the pain and anxiety questionnaires and the Headache Record and that you be requested to fill in either when you actually have the headache or immediately following your headache.

The first two visits complete the initial testing. The following two visits will occur after two separate headache episodes. During the time you are in a cluster period or within 24-72 hours of your last cluster headache, you will be requested to come into the Headache Centre and draw the location of your last headache in the same fashion as you did in the first two visits.

There are no significant risks or benefits for you to participate in this study since it does not change your course of treatment but simply documents your headache experience. There is a small risk that by focusing on your headache, you may feel more pain although the opposite may also be true. If you experience any difficulties during a cluster episode and wish to contact me; you may do so by contacting the Faulkner Hospital at 617-522-5800 and asking them to page Ruth Ann Fraser. You are free to withdraw from the research study at any time and for any reason and this withdrawal will not affect your future medical care.

I, _____ understand that I am being asked to participate in a study designed to document the location of the head pain in people diagnosed as having cluster headache. I understand that this study will not give me any direct benefits and that it will not affect my medical treatment. I give permission for the personnel associated with the study to examine my medical records and to collect the data for the study. This information will be kept confidential and I understand that my name will be known only to those who are directly involved with the study. If the results of this study are published, my name will not be used and my identity will remain confidential. I understand that my participation is voluntary and if I decide not to participate in the study or if I decide to stop participating at any time, my present or future care will not be prejudiced in any way. If I have any questions, I can contact Ruth Ann Fraser at 617-522-5800 or 617-522-6969 between 9am and 5pm. If you have any questions concerning your rights as a research subject, you may contact Lynn Fairbanks at 617-522-5800, Ext 1492.

I have received a copy of this consent form and I have read and understood it. I agree to participate in this study.

Patient's signature _____ Date _____

Witness's signature _____ Date _____

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Appendix 8

**Pictorial representations for Subjects 1 - 20 for
Sessions One and Two for
Onset and Peak Intensities.**

SUBJECT # 1

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 2

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 3

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 4

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 5

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 6

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 7

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 8

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 9

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 10

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 11

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 12

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 13

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 14

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 15

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 16

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 17

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 18

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 19

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

SUBJECT # 20

Session One - Onset

Session Two - Onset

Session One - Peak

Session Two - Peak

END

1 6-1 2-9 3

FIN