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The Effects of Chronic Migraine And Tension Headache On Neuropsychological Functioning

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THE EFFECTS OF CHRONIC MIGRAINE AND TENSION HEADACHE ON NEUROPSYCHOLOGICAL FUNCTIONING

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This dissertation meets the standards for appearance, conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

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ABSTRACT

The present study was designed to examine possible neuropsychological deficits in migraine and tension headache subjects. Past research has been inconclusive, with some studies indicating that chronic migraine headache sufferers do exhibit some neuropsychological deficits such as short-term memory difficulties, gross motor slowing, and verbal memory deficits, while other studies have indicated that no deficits are seen in this group Also examined were headache precipitant and headache-related behaviors that these groups partake in when experiencing headache pain. Past research has suggested that migraine headache sufferers tend to deal with their headache pain differently than tension headache sufferers.

Ninety undergraduate psychology students took part in a 1 1/2 hour testing session where they completed a series of questionnaires about their headaches and neuropsychological testing.

Analysis of questionnaire data revealed that both tension and migraine headache sufferers consistently attributed their headaches to the same types of precipitants, though they tended to cope with headache pain in different ways. Analysis of neuropsychological data revealed that once the effects of depression had been factored out by ANCOVA, no significant differences between migraine headache sufferers and the other groups existed. In fact, the migraine headache sufferers showed a tendency to perform better than the other groups while experiencing depression. Chi-square revealed a significant number of subjects from all three groups scored in the impaired range on many of the tests, though there were no significant differences between groups in the number of subjects scoring in the impaired range. It remains puzzling as to exactly why this is the case and findings certainly require replication. Future

neuropsychological investigations of migraine conducted longitudinally would be helpful in delineating the neuropsychological changes that may or may not occur in migraine headache sufferers.

CHAPTER I

INTRODUCTION

With the exception of epilepsy, headache has been known to the world of medicine longer than any disorder (Critchley, 1967). For over 3000 years, migraine headaches have been described in detailed accounts by many sufferers of the malady. Many famous people throughout history, such as Julius Caesar, Immanuel Kant, Edgar Allen Poe, and Tchaikovsky, have suffered from migraine headaches (Adler, Adler, & Friedman, 1987). It is estimated that over two million people, or about 1% of the population, suffer from incapacitating headaches each year (Feurstein, Labbe, & Kuczmeirczyk, 1986) and headache is the most commonly reported complaint in outpatient medical settings (De Lozier & Gangon, 1975). In the past century, hypotheses have abounded regarding various causes and cures of headache, but the fact remains that no specific cause or cure has been firmly identified.

Recurrent headache generally begins before the age of 40 and may appear prior to age five (Holroyd, 1986). Although headache affects all ages, races, and socioeconomic groups, it is estimated that women comprise approximately
60% to 75% of all migraine and tension headache sufferers (Andrasik & Krabela, 1988).

Although a variety of theories, ranging from physiological to psychological (e.g., Holroyd, 1986; Schucman & Thetford, 1970; Wolff, 1963) have attempted to explain the development and/or exacerbation of the treatment of headache disorders, we know relatively little regarding its genesis or its alleviation. Because of the great economic cost to employers and the personal costs to those who suffer from headache, much attention has been focused on the diagnosis and treatment of this disorder.

Headache Diagnosis

Headache classification has received considerable attention in the last two years. A new classification system for headache was recently developed and proposed by the Headache Classification Committee of the International Headache Society (1988). The most common types of headache reported by individuals fit into the categories of migraine with aura, migraine without aura, episodic tension headache, and chronic tension headache.

Migraine Headache

Migraine without aura. Migraine without aura, formerly common migraine, is described by the Headache Classification Committee (1988) as:

> Idiopathic, recurring headache disorder manifesting in attacks lasting 4-72 hours. Typical characteristics of headache are unilateral location, pulsating quality, moderate or severe intensity, aggravation by routine activity, and association with nausea, photo- and phonophobia (p.19).

In addition, most clinical researchers agree that migraine headache is characterized by a sudden onset, intense, sharp pain, and an average length of eight hours (Andrasik & Krabela, 1988). One or two headaches per month is the average frequency of migraine (Bakal, 1982). This form of migraine accounts for most of the debilitating cases of migraine (Headache Classification Committee, 1988).

Migraine with aura. Migraine with aura was formerly referred to as classical migraine and is described by the Headache Classification Committee (1988) as:

> Idiopathic, recurring disorder manifesting itself with attacks of neurological symptoms unequivocally localized to cerebral cortex or brain stem, usually gradually developed over 5-20 minutes and usually lasting less than 60 minutes.
>
> Headache, nausea, and/or photophobia usually follow neurological aura symptoms directly or after a free interval of less than an hour. The headache usually lasts 4-72 hours, but may be completely absent. (pp. 20-21)

Neurological symptoms that are commonly reported are scotoma (squiggly lines, blind spots, stars), paresthesia, field effects, vertigo, and nausea (Dalessio, 1987; Holroyd, 1986). These symptoms generally disappear before the onset of the headache (Bakal, 1982).

Pathophysiology of migraine. Migraine headache is thought to be of vascular origin. The prodromal phase is thought to be a result of vasoconstriction in the extra- and intracranial arteries which may cause blood flow to be reduced by up to 50% (Holroyd, 1986). The migraine headache itself is thought to originate from the subsequent dilation of cerebral blood vessels of the head, often thought to be the frontal branch of the superficial temporal artery. This may cause the characteristic throbbing pain reported by many migraine sufferers (Spierings, 1982). It has been hypothesized, however, that the pain that is perceived by migraineurs is not a sole function of vasoconstriction and dilation. It may be that the vasodilation is accompanied by a vasoactive substance that lowers the pain threshold in local tissues and increases pain vulnerability (Diamond & Dalessio, 1982; Raskin & Appenzeller, 1980). Penfield and Perot (1963) suggest that perhaps the area most involved in migraine is the occipital-cerebral region due to the depressive syndromes and changes in temporal and spatial schemes. The fact remains that the exact mechanism(s) for producing migraine headache pain is poorly understood at best (Headache Classification Committee, 1988).

Tension Headache

Tension headache, also called muscle contraction headache, is probably the most commonly reported form of headache pain. It is estimated that tension headache is diagnosed in approximately 80% of all headache-related complaints (Diamond, 1987; Waters, 1974). Fortunately, the pain is almost always considered less severe than migraine pain and is usually of much shorter duration (Kudrow, 1978). The tension headache is often diagnosed by exclusion of migraine symptoms, sinus-related problems, and organic origin (Philips, 1978). Frequency of occurrence may be the most reliable form of diagnosis with tension headaches occurring, on the average, two times per week while migraines occur much less frequently (Kudrow, 1978).

Episodic tension headache. Episodic tension headache, also referred to as muscle contraction headache and ordinary headache, is described by the Headache Classification Committee (1988) as:

> Recurrent episodes of headache lasting minutes to days. The pain is typically pressing/tightening in quality, of mild or moderate intensity, bilateral in location, and does not worsen with routine physical activity. Nausea is absent, but photophobia or phonophobia may be present. (p. 29)

This type of headache is commonly treated successfully with analgesics such as aspirin or ibuprofin.

Chronic tension headache. Chronic tension headache, formerly chronic daily headache, is characterized by the Headache Classification Committee (1988), as:

> Headache present for as least 15 days a month during at least 6 months. The headache is usually pressing/tightening in quality, mild or moderate in severity, bilateral and does not

worsen with routine physical activity. Nausea, photophobia, or phonophobia may occur. (p. 31)

This type of headache may begin as an episodic tension-type headache which becomes chronic in nature (Headache Classification Committee, 1988). This particular type of headache is commonly found in medical settings. This type of headache often responds to treatment with over-the-counter analgesics. However, because of the chronic nature of this disorder, many sufferers over-use these medications and may actually benefit when these medications are withdrawn (Kudrow, 1978).

Pathophysiology of tension headache. The Headache Classification Committee (1988) reports that the exact mechanism of these types of headaches is unknown at this time. The new criteria developed by the committee specifically leaves out the qualification of muscle tension state because of the fact that so little is known about the exact etiology of tension headache.

The most commonly accepted theory of the pathophysiology of tension headache is the muscle contraction theory. This theory posits that tension headache results from prolonged contraction of the muscles of the scalp, face, and neck (Martin, 1972). The Ad Hoc Committee (1962) reports that tension headache is a result of "sustained contraction of skeletal muscles in the absence of permanent structural change, usually as part of the individual's reaction during life stress" (p. 718). The pain associated with this muscle contraction is considered to be produced by stimulation of the pain receptors in the contracted muscles and ischemia resulting from the constriction of intramuscular arterioles (Haynes, 1980).

Although this theory is generally acknowledged as the dominant model in the headache literature, the empirical evidence is equivocal (Chapman, 1986; Hursey, Holroyd, Penzein, & Holm, 1985). Chapman reviewed 28 studies that compared frontalis electromyogram (EMG) activity of tension headache sufferers to headache-free controls and found that only nine of the studies found tension headache sufferers to have elevated EMG levels. Six of the studies had mixed results and 13 showed no significant differences between groups. The nine studies that did find differences between groups had many methodological flaws. Chapman reports that those studies that did not show differences between groups were more methodologically sound than those that did show differences between groups. For example, Hursey et al. (1985) found that tension headache sufferers show significant differences in EMG only when they are experiencing a headache. When the headache sufferers were not experiencing any head pain, their muscular reactivity was the same as non-headache sufferers. Hursey et al. argue that the failure to control for pain state is a major flaw that may account for the lack of agreement in past research. This argument is reiterated in Chapman.

Psychobiological Model of Headache

As a result of the inadequacies of the dominant biological models of headache, other models have sprung up in an attempt to more fully explain the etiology of headache and to challenge the current theories of headache etiology. The most notable of these recent theories is the psychobiological model.

There has been an increasing body of literature that suggests that headache is not the sole result of biological processes (Bakal, 1982; Holroyd, 1986). As stated before, Chapman (1986) reports that tension headache sufferers are not necessarily characterized by heightened skeletal muscle activity and Hursey et al. (1985) report that tension headache sufferers do not show unusual muscular responses to stressful situations. It has also been demonstrated that migraine headache sufferers do report headaches in the absence of temporal artery vasodilation (Feurstein, Bortolussi, Houle, & Labbe, 1983).

Bakal (1975) has proposed a psychobiological model of chronic headache which considers chronic headache to be an intricate transaction between psychological, environmental, physiological, biochemical, and genetic factors. Bakal uses the term transaction to indicate the interplay between the variables which mutually influence one another. This model assumes a holistic approach to the understanding of the chronic headache condition, with consequent implications for treatment.

Bakal (1975) indicates that a crucial characteristic of the chronic headache sufferer is his/her psychobiological predisposition. He hypothesizes that the chronicity of the headache patient's condition can be accounted for by this predisposition. The predisposition is comprised of psychological and physiological variables which initiate the physiochemical changes that occur in chronic headache. Bakal also hypothesizes that the psychobiological predisposition mediates headache attacks that are triggered by known precipitants (such as dietary tyramine, lack of sleep, and bright lights) as well as those headaches that occur in the absence of known precipitants. Bakal believes that the genetic component of headache is an indirect variable and much less significant than other variables, such as behavioral and environmental variables including the headache sufferer's ability to cope with the chronic headache condition.

Although this model of headache has gained attention in recent years, empirical support for the model has yet to be demonstrated. Therefore, little has changed regarding understanding of headache etiology or ability to either provide symptom relief or ultimately, a cure for the disorder. It is safe to say that headache continues to baffle the scientific community and remains a complex, little understood disorder. Perhaps further understanding of the etiology of this baffling disorder will be forthcoming through studies examining neurological changes associated with headache.

Neurological Changes During Headache

Computerized Axial Tomography

The suggestion that migraine headache may cause permanent central nervous system damage is by no means a new idea. Charcot was cited as saying that any neurological damage from migraine that occurs transiently may become permanent in time (Buckley, 1978). Charcot also suggested that perhaps this damage may be the result of vasospasms that could cause vascular occlusions. One way in which researchers have attempted to test this theory has been through the use of Computerized Axial Tomography (CT-Scans). The results from CT-scans of migraine patients have been inconclusive.

The first CT finding that migraine causes some focal edema occurred as the result of a staff member who volunteered to be the first to test a recently installed CT-scanner at the Mayo Clinic (Baker, 1975). Focal edema appeared on the volunteer's CT-scan shortly after a migraine attack. In studies that have been done since that time, abnormal CT-scans have been reported in 24%-76% of migraine headache patients (Cala & Mastaglia, 1976, 1980). For example, Sargent (1979) conducted a study on 129 patients who had much less severe migraines than those reported in Cala and Mastaglia, and they reported that 25% of the patients showed CT-scan abnormalities. Sargent et al. (1979) found that 28% of the migraine subjects in their study showed abnormal CT-scans with 28% of these subjects showing cortical atrophy, and the remainder showing diffuse damage. The majority of the damage was localized in the temporal lobe.

In past studies, results from CT-scans have verified zones of edema compatible with the symptomology of migraine (Bousser, Baron, Iba-Zizen, Comar, Cabanis, & Castaigne, 1980; Cohen & Taylor, 1979; Dorfman, Marshall, & Enzmann, 1979). A study conducted by Cala and Mastaglia (1976) revealed that 35 of 46 patients studied had visible infarcts, edema, or atrophy on CT-scans. They have suggested that focal damage may occur due to vasospasms that occur during migraine attacks. Mathew, Meyer, Welch, and Neblett (1977) were also able to detect areas of infarct and edema in the CT-scans of migraine headache sufferers. There have also been studies that have shown normal CT-scans in the presence of neuropsychological deficits (such as increased reaction time) and abnormal electroencephalogram (EEG) activity in the area of the brain corresponding to migraine symptomology (Levy, 1981). Levy asserts that these abnormalities indicate that lesions associated with migraine headache may be too small to be identified by CT-scan and other means for finding problem areas must be utilized. Connor (1962) presents 18 cases of migraine that presented at Cardiff Royal Infirmary between 1953 and 1961, all of which had some sort of permanent lesion believed to have been caused or contributed to by migraine headache. Connor points out that the lesions found among migraine headache subjects may be more common than previously thought. He explains that these findings support the suggestion that migraine can cause an organic lesion in the nervous system which may result from long and severe spasms, vascular obstructions, or hemorrhage.

Several post-mortem studies of fatal complicated migraine have found areas of ischemia and edema. A case in point is that of a 28 year old man who reported a two-year history of migraine headache. The fatal attack resulted in a right hemiparesis and a semicomatose state that ended in death after 20 hours. The examination of the brain revealed extensive ischemic changes and small hemorrhages throughout the left cerebral hemisphere, particularly in the superior and middle frontal gyri. Regions of the brain stem also exhibited some ischemia, however, the internal carotid and anterior and middle cerebral arteries were normal (Guest & Woolf, 1964).

The above studies indicate some degree of infarction or ischemia in most migraine headache patients that were tested. However, none of these studies controlled for age of subject or chronicity of headaches.

This would appear prudent since the rate of infarction and ischemia increases with age. Also, controlling for such variables would better enable researchers to determine whether the ischemia/infarct that is present: (a) results from repeated migraine attacks; (b) causes the repeated attacks; or (c) is associated with migraines through a common underlying process.

Cerebral Blood Flow Studies

The reduction in regional cerebral blood flow in migraine headache has been well documented in the literature (e.g., Oleson, Larsen, & Lauritzen, 1981; Symonds, 1952; Wolff, 1963). The common conception of a migraine attack includes an initial period of vasoconstriction which may be the cause of focal ischemia which often appears at the same time. After this constriction, a vasodilation begins during which time the headache occurs. It is also thought that because of this pain, cerebral metabolism increases which contributes to further vasodilation which contributes to
more pain, thus creating a positive feedback loop (Connor, 1962).

Sakai and Meyer (1979) believed that the available literature concerning the pathogenesis of migraine headache was incomplete, but suggestive of excessive cerebral vasomotor responsiveness being part of the precipitating mechanisms responsible for producing migraine symptoms. Sakai and Meyer confirmed reports that cerebral blood flow measurements during the prodromal phase of classic migraine were less than those of other headache sufferers after subjects' inhalation of 100% oxygen. Sakai and Meyer also report that the changes in cerebral blood flow in these patients causes neurological deficits due to cerebral ischemia similar to those found in transient cerebral ischemic attacks (TIAs) which frequently lead to atherothrombic stroke. Sakai and Meyer hypothesize that in migraine, there is a release of vasoactive amines and neurotransmitter substances onto the receptors of cerebral vessels and into cerebral interstitial fluid which either accompanies or is secondary to the initial regional cerebral ischemia, and that this may play an important role in the spreading vasoparalysis, vasodilation, and impaired cerebral function which is characteristic of the migraine.

Oleson et al. (1981) report that in the eight patients they studied, they found results similar to those reported above by Sakai and Meyer. Regional blood flow changes occurred during the prodromal and headache stages of migraine. During the aura, all patients displayed occipitoparietal regional reduction which spread anteriorly over 15 to 45 minutes. It was concluded that alterations in neuronal functioning better explain the symptoms of migraine than arterial spasms and that the reduced regional cerebral blood flow (rCBF) may be secondary to lowered metabolic requirements of the depressed cells.

A number of other studies report similar findings to those reported above (e.g., O'Brien, 1967; Simard & Paulsen, 1973) . All have found that there is a definite pattern of change in regional cerebral blood flow prior to and during the headache phase of migraine headache sufferers.

Headache and Neuropsychological Deficits

Studies that have looked at the possibility of neurological deficits in headache sufferers have yielded conflicting findings. Most studies however, have shown that migraine headache sufferers do exhibit some neurological deficits even when they are not experiencing headache pain. Schucman and Thetford (1970) attempted to determine whether migraine headache caused cognitive deficits in migraine patients. They tested 29 migraine subjects between the ages of 18 and 40 years. They found that scores for migraine patients on the Wechsler Adult Intelligence Scale digit span were significantly lower than controls, indicating that attention and immediate recall (short-term memory) in these patients may have been affected by repeated headache. However, many problems with this study are apparent. First, Schucman and Thetford did not specify the approximate length of time that subjects had suffered from headache and no attempt was made to control for medication use among subjects.

In a more recent study, Covelli, Antonaci, and Puca (1984) assessed the degree of memory impairment in migraine headache sufferers. Covelli et al. utilized subjects who had a headache history of five or more years and who had not taken any type of headache medication for at least 10 days. All subjects were tested in a pain-free state. They found evidence of greatest impairment in short-term memory and a lesser level of impairment in logical memory, visual reproduction, and associate learning. They suggest that this is indicative of central brain dysfunction. Data also indicate that memory deficits seem to be related to the age of onset and illness duration. Covelli et al. do not report effects of medication on performance and took no medication history from their subjects. There was also no age-exclusion rate for subjects.

Zeitlan and Oddy (1984) also attempted to detect neuropsychological deficits among migraine headache patients. Nineteen subjects who had all suffered from migraine headaches for a minimum of 10 years were studied. Subjects ranged in age from 20-50 years of age and spouses of subjects were used as controls when possible. Zeitlan and Oddy reported significant differences between migraine headache patients and controls in many areas of neuropsychological functioning. There was a significant difference between migraine and control subjects in reaction time, which was thought to result from differences in motor speed rather than a decision-making component. The migraine subjects also showed less efficient information processing and poorer verbal memory (as measured by the WAIS Digit Span subscale) than controls. Zeitlan and Oddy did attempt to control for medication use by ensuring that no medication had been taken on the day of testing and subjects who used only abortive medications (e.g., ergotamine tartrate) could take part in the study. The results did not support the suggestion that drug use could explain the identified deficits. Results also did not indicate that those subjects with longer history of headache were more impaired than those with shorter headache history. Hooker and Raskin (1986) found that both classic and common migraine patients had poorer ability to discriminate forms and to analyze visual and verbal relations and had poorer delayed recall for semantic material than controls. The migraine sufferers also made more errors in the Aphasia Screening Test and showed less dexterity than controls. The authors also reported no correlation between medication use and severity of deficits, and no correlation between chronicity of headache and level of impairment.

Most recently, Leijdekker, Passchier, Goudswaard, Menges, and Orlebeke (1990) looked at 37 females with migraine histories of seven or more years. Subjects were matched for age, education, and social background and none were over 50 years of age. All subjects were asked to reduce medication intake as much as possible before testing, but not to go off medication completely. Leijdekker et al. found no differences between migraine patients and controls in reaction time, motor speed, psychomotor abilities, and short and long term memory. They also found no influence of medication when patients using medication were compared to those who did not use medication. There were also no differences in test performance reported between patients using ergotamine, analgesics, or patients not using drugs and control groups. Length of drug use was not examined because of the lack of findings between patients in the initial assessments of neuropsychological functioning. There was also no correlation between chronicity of headache and the neuropsychological impairment level of migraine subjects. The authors go on to speculate that the cumulative effect of migraine attacks on the cognitive performance of migraine patients is nonexistent.

Although all of the previously mentioned studies utilized some type of control group and many attempted to control for medication use, methodological concerns still exist. For example, many of the studies "controlled" for medication use by simply requesting that the patient refrain from drug use on the day of testing or a short period of time before testing. This was assumed to be sufficient in many cases as a way of controlling drug intake. In none of the reported studies was drug-use used as a covariate. Coyne, Sargent, Segerson, and Obourn (1976) have suggested a potency scale that can be used as a means of quantifying patients' drug use. This scale gives a weighted formula that includes many drugs commonly used in the treatment of migraine and tension headache such as meperdine hydrochloride, codeine sulfate, propoxyphene hydrochloride, and common over-the-counter analgesics.

In addition to concerns over adequate control of medication use, conflicting evidence exists as to whether the length of time that the subject has suffered from headache is a significant factor in the degree of neurological impairment shown by the headache sufferer However, most studies have required that their subjects have had headaches for at least a five-year period. Therefore, little is known regarding relatively young, nonchronic headache samples. It is possible that perhaps it is not the repeated headache attacks that cause these neuropsychological deficits, but rather the deficits are caused by some form of ischemia that also causes headache pain (particularly, migraine pain). It is also true that headache diagnosis for many studies has taken various forms from a neurologists' diagnosis of migraine or tension headache, or various diagnostic systems commonly employed in the country in which the research was conducted. Since there is currently a set of diagnostic criteria for the determination of headache type, it would seem beneficial to use these criterion to diagnose all possible subjects for headache research. Finally, no studies have controlled for the frequency, intensity, or duration of the head pain. In other words, subjects experiencing one migraine headache per month have been grouped together with those experiencing up to 10 headaches per month in migraine samples. In tension headache sufferers, those individuals suffering from headaches on the average of three headaches per week have been grouped with those experiencing up to four or five headaches per day.

Proposed Study

The proposed study investigates the relationship between recurrent migraine and tension headache and neuropsychological function. Frequently studies have compared either muscle contraction or migraine headache patients with headache-free control groups or have simultaneously compared the two groups to each other. However, very few studies have compared migraine and tension headache sufferers with headache-free controls. The current study focuses on the possibility of migraine attacks causing neurological deficits. There are innumerable studies that have documented the damage that is often present in the migraine patient, however few have utilized a relatively young population with a short history of headache. Such a population should show fewer neuropsychological deficits in general since neuropsychological deficits increase with age and fewer deficits from repeated migraine attacks. However, it follows that if a population with a relatively brief headache history were to display these same deficits, perhaps the migraine itself is responsible for these deficits or the deficits are secondary to some other underlying process. The current study will control for medication use by utilizing the Coyne et al. (1976) formula for estimation of medication use and using this number as a covariate. It is assumed that since this is a less chronic population than those utilized in previous studies, the medication usage will be nearly negligible. However, this attempt to control for medication use will still be made. Differences in headache activity will also be controlled for through use of a more stringent screening form that will eliminate those subject who have experienced headache pain for greater than eight years, and those who have experienced migraine headaches within the past 96 hours. All subjects will be asked to report average usage of medications of any kind, the length of time they have experienced problematic headaches, and whether or not they are experiencing headaches at the time of testing. It is hypothesized that migraine headache subjects will exhibit significantly greater average neuropsychological impairment and a greater percentage of tests scored in the impaired range than tension headache sufferers and headache free controls.

CHAPTER II

METHOD

Subjects

Ninety students enrolled in undergraduate psychology courses at the University of North Dakota participated in this study. Subjects ranged in age from 18 to 25 years. Subjects were placed into one of three groups during a three-phase screening process: (a) vascular headache (N=30), (b) tension headache (N=30), and (c) headache-free controls (N=30). All subjects were awarded extra credit for their participation in the study.

Only one of the 90 subjects was taking prescription medications for headache pain. This subject's data was not used for the purposes of the study and no analyses were completed regarding medication use.

Screening

Approximately 1000 students enrolled in undergraduate psychology classes during the spring semester of 1990 and the fall semester of 1991 completed the initial screening questionnaire. The questionnaire assessed headache frequency, intensity, prodromal symptoms, location of pain, and family history of headache. This questionnaire allowed for the initial differentiation of headache type by head pain quality and location.

In the second stage of the screening process, subjects were contacted by phone by a psychology graduate student trained to differentiate types of headache through use of diagnostic criteria set forth by the Headache Classification Committee of the International Headache Society (1988). To be eligible for participation in the study, subjects with vascular headaches had to have at least one headache per month and had to meet the following criteria (pp. 19-21):

A. At least 5 attacks fulfilling B-D

B. Headache attacks lasting 4-72 hours (untreated or successfully treated).

C. Headache has at least two of the following characteristics:

1. Unilateral location
2. Pulsating quality
3. Moderate or severe intensity (inhibits or prohibits daily activities)
4. Aggravation by walking stairs or similar routine physical activity

D. During headache at least one of the following:

1. Nausea or vomiting
2. Photophobia or phonophobia

E. No history of physical or neurological disorders causing or contributing to the headaches

OR

A. At least 2 attacks fulfilling B

B. At least 3 of the following 4 characteristics:

1. One or more fully reversible aura symptoms indicating focal cerebral cortical and/or brain stem dysfunction.
2. At least one aura symptom developed gradually over more than 4 minutes or, 2 or more symptoms occur in succession.
3. No aura symptom lasts more than 60 minutes. If more than one aura symptom is present, accepted duration is proportionally increased.
4. Headache follows aura with free interval of less than 60 minutes (it may also begin before or simultaneously with the aura).

C. No history of physical or neurological disorder causing or contributing to the headache.

Tension headache subjects had to have at least three headaches per week and had to meet the criteria set forth by the Headache Classification Committee (pp. 29-30, 31-32):

A. At least 10 previous headache episodes fulfilling criteria B-D listed below. Number of days with such headache <180/year (<15/month).

B. Headache lasting from 30 minutes to seven days.

C. At least two of the following characteristics:

   1. Pressing/tightening (non-pulsating) quality

   2. Mild or moderate intensity (may inhibit, but does not prohibit activities)

   3. Bilateral location

   4. No aggravation by walking stairs or similar routine physical activity

D. Both of the following:

   1. No nausea or vomiting (anorexia may occur)

   2. Photophobia and phonophobia are absent, or one but not the other is present

E. History, physical- and neurological examination do not suggest organic etiology

To be included in the headache-free control group, subjects had to meet the following three criteria:

A. headaches occur no more than once every two months.

B. no independent diagnosis of vascular headache.

C. no report of migraine-related symptoms.

Subjects were excluded from any of these groups if they met either of the following two criteria:

A. patient with chronic head pain that does not meet the above inclusion criteria.

B. patients who display evidence of possible neurological impairment (e.g., recent onset of headaches, dramatic shifts in symptom patterns).

The third stage of the screening process involved a personal diagnostic interview. This interview assessed areas such as current pain state of the subject, previous head injuries, medication use, chronicity of headache, severity of headaches, and some demographic information (e.g., age, race, gender). The evaluation was administered by a graduate student trained in the headache interviewing process. This screening gave further clarification as to the exact type of headache.

Materials

The test materials in this study consisted of the Beck Depression Inventory (BDI), the Shipley Institute of Living Scale, the Wechsler Memory Scale, Trail Making Test, the California Verbal Learning Test, Finger Oscillation Test, the Stroop Color and Word Test- Golden Version, The Wisconsin Card Sort Test, the Sternberg, and a simple test of reaction time. The tests were given in the above stated order.

Beck Depression Inventory (BDI)

The BDI (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) is a 21-item inventory which is widely used for the assessment of depressive symptoms. The 21 categories of responses cover affective, cognitive, motivational, and physiological areas of depressive symptomology. Beck et al. have demonstrated that individuals' scores on each of the 21 categories are significantly related to their total score on the inventory. Early validation studies (c.f., Beck et al., 1961) in psychiatric populations demonstrated high split-half reliability (Pearson r=.86) and substantial agreement between BDI scores and clinical ratings (Pearson biserial r= .65 and .67).

The issue of using the BDI with university populations has been addressed by several studies (Bumberry, Oliver & McClure, 1978; Hammen &

Padesky, 1977). These studies as a whole suggest that in a university population, the BDI has adequate test-retest reliability over a three-week period (.78), good agreement with clinical ratings (.77), and was not significantly associated with sex, marital status, or age. Therefore, it appears that the BDI is a valid instrument for measuring depression in university populations.

The BDI was used to assess the level of depression (if any) each subject presented with. Due to the fact that depression may cause decreased performance in subjects, those subjects scoring higher than 14 on the BDI were not allowed to participate in the study.

Shipley Institute of Living Scale (SILS)

The SILS (Shipley, 1946) consists of two parts, a group of 40 multiple choice vocabulary items and a set of 20 open-ended series that require the subject to abstract the rule in order to determine the next element. The subject is given 10-minutes for each portion of the test. A Vocabulary and an Abstraction score are found. A total score is also found for the test which is obtained by adding the sum of correct answers from the Vocabulary test and the doubled Abstraction score and looking up these numbers on a standardized chart to find an estimated IQ. The Shipley is frequently used in research studies as a rough estimate of IQ or as a matching variable. Shipley assessed the reliability of the scales with a sample of Army recruits. He reports odd-even correlations of .87 (Vocabulary), .89 (Abstraction), and .92 (total score). Many studies have found similar reliability estimates (e.g., Manson & Grayson, 1947; Martin, Blair, Stokes, & Lester, 1977). For the purposes of this study, the Shipley was utilized as a rough estimate of IQ to ensure that the IQ differences between groups are negligible.

Wechsler Memory Scale (WMS)

The WMS is a battery that assesses all major aspects of the memory system. It consists of seven subtests. The first subtest, Personal and

Current Information, asks questions regarding the subject's age, birthdate, and current public officials. The second subtest, Orientation, asks questions about time and place. The third subtest, mental control, tests automisms and conceptual tracking (e.g., count by threes beginning with the number 1). Subtest four tests for immediate recall of brief prose passages (Logical Memory). The fifth subtest tests immediate recall of serial digits, both forward and backward (Digit Span). The sixth subtest tests immediate recall of simple geometric designs (Visual Reproduction). And finally, the seventh subtest tests verbal retention (Lezak, 1983). This test is thought to be a good test of verbal and visual memory and is fairly accurate in helping to identify memory disorders associated with diffuse, bilateral, and left hemisphere lesions (Lezak, 1983).

Trail Making Test

The Trail Making Test (Reitan, 1955b), is a test of visual conceptual and visual-motor tracking, which is highly vulnerable to the effects of brain injury. It consists of two parts, A and B. Trails A consists of 25 circles containing the numbers from 1 to 25. The subject is instructed to connect the circles in numeric order as quickly as possible. Part B also contains 25 circles that contain either a number or a letter. The subject is asked to connect the circles as quickly as possible by alternating between numbers and letters, beginning with number 1 (1-A-2-B-3, etc.). Before each test, a practice page is presented. Mistakes made during the timed portion of the test are corrected immediately by the examiner. These mistakes are noted and become part of the final score along with the number of seconds for completion. The final score for this test is represented by the B-to-A ratio.

Both parts of the test require coordination and fine motor skill, visual scanning, and the ability to maintain and integrate two simultaneous sets of symbols while alternating between them. This test assessed for lateralization of brain damage.

California Verbal Learning Test

The CVLT measures immediate memory span, provides a learning curve, reveals learning strategies, elicits retroactive and proactive interference tendencies, tendencies to confabulate, and delayed retention (Delis, Kramer, Kaplan, & Ober, 1987). In this test, the subject receives five presentations of a 16-item word list, one presentation of a second 16-item word list, a short-delay recall, a long-delay recall, and a long-delay recognition trial. The examiner reads the words at the rate of one per second and asks for immediate recall of the words. The words are recorded for each of the five trials in the order that the subject recall them. The examiner then reads a second word list to the subject and asks the subject to recall these words immediately. This is intended as an interference task. The examiner then asks the subject to recall all of the words from the first word list. The subject is then asked to recall the word list following a 20-minute delay. After this task, the subject is given semantic cues for words from the list and a recognition trial in order to aid retrieval of the initial word list. A total score for sum of all words is found and individual scores on each trial are also noted.

Finger Tapping Test

This test (Reitan & Davidson, 1974) is a portion of the Halstead-Reitan Neuropsychological Battery and Allied Procedures and is the most widely used test of manual dexterity (Lezak, 1983). It is a simple test of fine motor coordination and speed. The subject places his/her hand palm down on the table and rests the index finger on the lever that is connected to a counter. The subject is then told to tap on the lever as fast as possible for a ten-second period with the dominant and then the nondominant hand. Subjects perform three 10-second trials with each hand and the average across the three trials is found. A 10-12%

advantage is usually found in the dominant hand. Finger tapping speed deficits indicate contralateral frontal lobe dysfunction. Lateralized lesions may cause a slowing in the hand contralateral to the lesion and diffuse damage will lead to a generalized slowing in both hands. Although individual reliability for this test is not available, the entire test battery itself is highly effective in identifying brain-damaged and non-brain-damaged individuals beyond the .001 level of significance (Reitan, 1955a). Matarazzo, Weins, Matarazzo, and Goldstein (1974) report that the overall reliability of the Halstead-Reitan is very high and that it provides a consistent and reliable measure of patients with organic and non-organic brain damage.

Stroop Color-Word Test- Golden Version

The Stroop Color-Word test (Golden, 1975) is a test of verbal fluency and cognitive efficiency. It is thought to be a good indicator of an individual's ability to shift his/her perceptual set and conform to changing demands (Lezak, 1983). The test consists of three 8 1/2-by-11 inch white pages. Each word on the first page is the word "red", the word "green", or the word "blue". There are 100 words that are randomly repeated throughout this page. On page two, there are also 100 items, however, these items are four X's (XXXX) printed in one of the three previously mentioned colors. The third page consists of the same words that are printed on page one, however, they are printed in the colors that are on page two (i.e., the words are printed in red, blue or green ink). The words and the color on which the words on page three are printed in do not match (i.e., the word "red" would be printed in either green or blue ink). The directions for page one require the subject to read the words on the page out loud as quickly as possible. For page two, the subject is asked to name the color of the XXXX's on the page as quickly as possible. On the third page, the subject is asked to give the name of the color of the ink in which the word is written. The subject gets 45 seconds to complete each card. The score is the number of items correctly finished on each page within the time limit.

Reliability for the Stroop Test-Golden Version are reported to be .86 for card 1, .82 for card 2, and .73 for card 3 for the individual administration (Jensen, 1965).

Wisconsin Card Sorting Test (WCST)

The WCST (Berg, 1948) consists of four cards which are placed in front of the subject left to right. The cards are pictures of a red triangle, two green stars, three yellow crosses, and four blue circles. The subject is given a deck of 64 cards, each with a unique combination of the three characteristics of color, form, and number. No two cards are alike. The subject is told to put the card in front of the card that s/he thinks is correct. The examiner responds to the subject card placement only by saying "right" or "wrong". The object of the sorting task is to correctly sort 10 cards to the principle that the examiner is adhering to. Once the subject has successfully sorted 10 cards, the rule is changed, however, the subject is not informed of the change. The order that the examiner uses for the rules is color-form-number-color-form-number. The test is completed when all six categories have been completed or when the subject exhausts two decks of 64 cards (Heaton, 1981). This test is a good indicator of a subject's ability to form abstract concepts. Subjects who experience difficulty in this task frequently show frontal lobe dysfunction. Perseveration on this task may indicate anterior brain damage. In a comprehensive reliability study conducted by Heaton using over 350 patients, cutoff scores for brain-damage were provided with correct classification at the 70% plus range.

Reaction Time

In the reaction time test, a figure is displayed on a computer screen and the subject is told to press the space bar when the figure appears. This test is a test of lateralization of brain dysfunction.

Lesions in either the right or left hemisphere slow reaction time. However, right hemisphere lesion cause greater reaction time slowing than left hemisphere lesions (Heilman, Watson, & Valenstein, 1985).

The Sternberg Test

The Sternberg memory scanning task (Sternberg, 1966) requires a subject to first memorize a series of one to six items presented sequentially at 2-second intervals. This presentation is followed immediately by a probe stimulus. The subject must decide immediately whether or not the probe is one of the symbols of the previously presented set. Response latency is recorded beginning with the onset of the probe stimulus to the occurrence of the response. This is a test of short-term visual memory processes.

Procedure

At the time of the second screening, subjects were scheduled for an appointment to complete the headache interview and neuropsychological testing. Subjects were scheduled for a 2 1/2-hour period in which to complete the interview and testing. All subjects were tested between the hours of 2:00 p.m. and 8:00 p.m. in order to maintain some degree of control over time of day effects. Subjects were tested only if they reported that they were not experiencing a headache prior to the start of testing. They were also requested to abstain from alcohol and medication use for the 24-hour period preceding their scheduled testing. Any subject who reported experiencing a migraine headache within the past 96 hours was rescheduled. The interview and testing were conducted by graduate students trained in headache interviewing techniques and the administration of the previously mentioned tests. The students who administered the test also filled out a brief questionnaire that assessed the current motivational level of the subject. Prior to the interview and administration of the tests, informed consent was obtained from the subjects. The order of the testing was standardized so as to minimize variability of data. After completion of the testing, each subject received an extra credit slip and was able to place his/her name on a list to receive the results from the study upon completion of the experiment.

CHAPTER III

RESULTS

Overview of Analyses

First, descriptive statistics were computed for each of the dependent variables. These analyses were done separately for males and females and the three headache groups. Next, a series of 2 (Gender) by 3 (Headache Status) analyses of covariance (ANCOVA) were performed on the neuropsychological test data. ANCOVA was used to analyze neuropsychological data in order to factor out depression (BDI scores), which has been shown to have an effect on neuropsychological performance (Henry, Weingartner, & Murphy, 1973). Before completing ANCOVA, a test of parallelism was conducted to determine whether the effect of the covariate, depression, was similar across the six cells of the design. If the test was significant, then the effect of the covariate was calculated separately for each cell in the design. If this test was not significant, then the effect of the covariate was calculated jointly for all subjects, regardless of group membership. The one exception to this was the analysis for the Sternberg on which a 2 (gender) by 3 (headache status) by 3 (trial) mixed design ANCOVA with two between subject factors and one within (trial). No test of parallelism was completed for this analysis. Finally, Chi-square analyses were computed for neuropsychological data using established norms and cut-off levels for each individual neuropsychological test. In these analyses, the number of subjects in the impaired and unimpaired ranges were compared to the numbers expected based on available norms for each test. These chi-square analyses were done separately for each headache group. Finally, chi-square analyses were also performed to compare the number of migraine, tension, and control subjects scoring in the impaired range on each test.

Table 1 summarizes the participants mean age, length of time experiencing headache, and number of headaches they experience per week.

Headache Precipitant and Behaviors

A questionnaire addressing headache precipitants and headache behaviors was completed by each subject. On this questionnaire, they recorded whether or not each precipitant triggered a headache or whether or not they partook in a particular behavior while experiencing a headache. Subjects rated each item on a 7 point Likert scale where 1=never, 2=rarely, 3=occasionally, 4=sometimes, 5=often, 6=usually, and 7=always. To improve clarity, descriptive analyses were conducted by categorizing subjects as either "characteristic" (scores of 4, 5, 6, or 7) or "uncharacteristic" (scores of 1, 2, or 3) on each item. Frequencies and percentages for the items pertaining to headache precipitants are found in Figure 1. Figures 2 through 5 contain the frequencies and percentages for the items pertaining to headache

Table 1

Mean Age, Number of Years Experiencing Headache, and Number of Headaches per Week

	Age	# Years	# Headaches/Week
Male			
Control	20.4	---	.26
Tension	20.3	6.9	3.50
Migraine	19.1	4.43	1.68
Female			
Control	20.2	---	.25
Tension	19.8	8.65	4.25
Migraine	20.7	4.98	1.60

behaviors for the two headache groups. In both male and female control groups, there were no items that were endorsed that consistently caused headaches and no behaviors that were engaged in on a regular basis while experiencing headaches.

Test Data Analyses

Several 2(Gender) X 3(Headache Status) analyses of covariance (ANCOVA) were performed to examine group differences on neuropsychological data controlling for subjects' level of depression. As discussed previously, before conducting ANCOVAs, tests of parallelism were performed to determine whether it was necessary to calculate separate regressions for each group in determining the effect of depression on the dependent variable. Only significant results ($p < .05$) will be reported in the following paragraphs.

Shipley Institute of Living Scale. ANCOVA yielded no significant effect of the covariate or group factors for this measure as a whole, or its two subscales.

Wechsler Memory Scale (WMS). First, the test for parallelism for the overall score on the WMS was significant, indicating that the effect of depression would have to be independently calculated for each subject group [F (5,78)=3.28, p=.01]. Analyses revealed a significant effect for the covariate (Beck Depression Inventory; BDI) within the main effect for headache status [F (3,78)=3.28, p=.019] and the headache status by gender interaction [F (2,78)=5.25, p=.007]. After removing the effect of the covariate, analyses also showed a significant headache status by gender interaction on the WMS [F (2,78)=4.08, p=.021].

Tests of simple effects were used to follow-up the significant headache status by gender interaction. These tests revealed a significant difference [F (1,80)=9.82, p=.002] between male and female tension headache subjects with males (M = 106.9) scoring significantly lower than females (M = 111.05) on the WMS.

The effect of the covariate, BDI score, on the WMS can be seen by examining regression coefficients between BDI and WMS. Since there was a significant effect of BDI within the Headache status by Gender interaction, it is necessary to examine the regression coefficients for all six cells of the study's design. As shown in Table 5, negative correlations between the BDI and the WMS were found in male and female controls and female tension headache subjects, while positive correlations were found in male tension and female migraine headache groups.

Finally, ANCOVA yielded significant effects on the paired associates subtest of the WMS. A significant test of parallelism was found for the paired associates subtest [F (5,78)=2.92, p=.018]. However, neither the covariate nor the group factors were found to have significant effects on the paired associates subtest.

There were no significant effects for any of the remaining subscales of the WMS.

Finger Tapping Test. ANCOVA yielded a significant main effect for gender for finger tapping speed with the dominant hand [F (1,83)=18.55, p=.000]. Table 2 contains the group means for all significant main effects for gender. No other significant effects were found for this test.

Stroop Test. ANCOVA revealed no significant effects for the three trials of the Stroop test. However, ANCOVA revealed a significant gender by headache status interaction for the number of errors committed on the first stroop task [F (2,83)=3.73, p=.028] (see Figure 6). Subsequent tests of simple effects, however, found no significant

Figure 1

Frequencies of Selected Headache Precipitants of Tension and Migraine Subjects

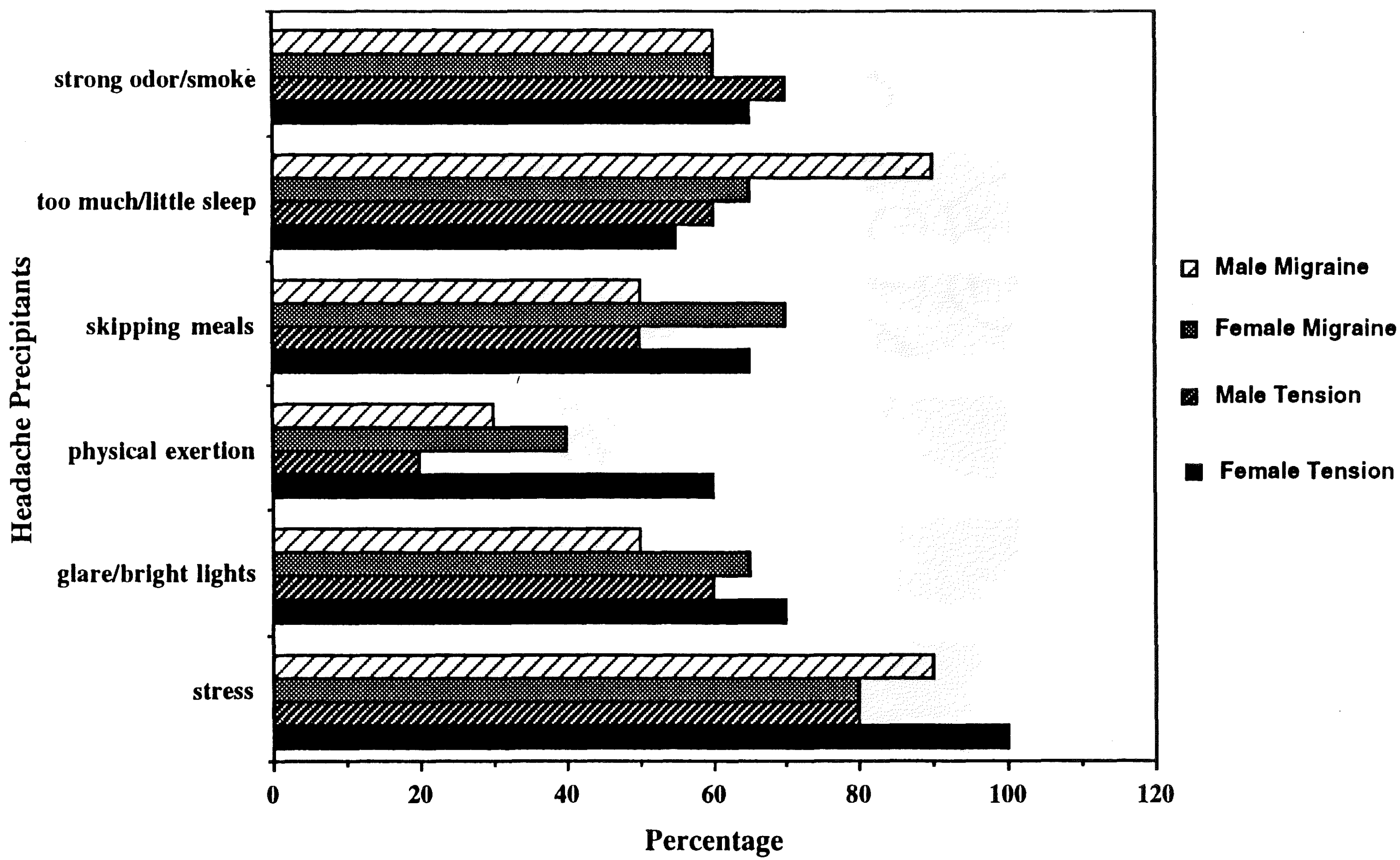


Figure 2

Frequencies of Selected Behaviors of Female Tension Headache Subjects

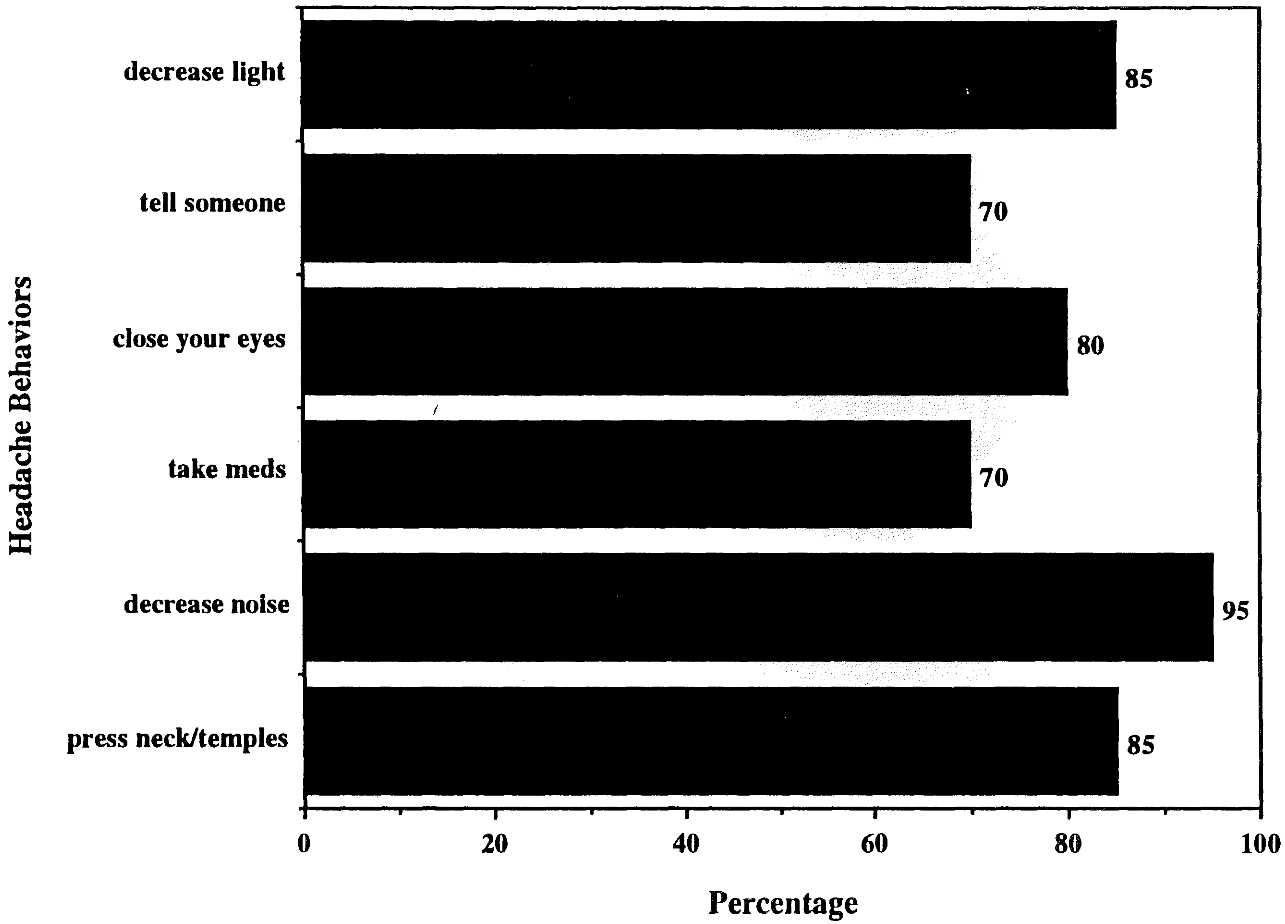


Figure 3

Frequencies of Selected Behaviors of Female Migraine Headache Subjects

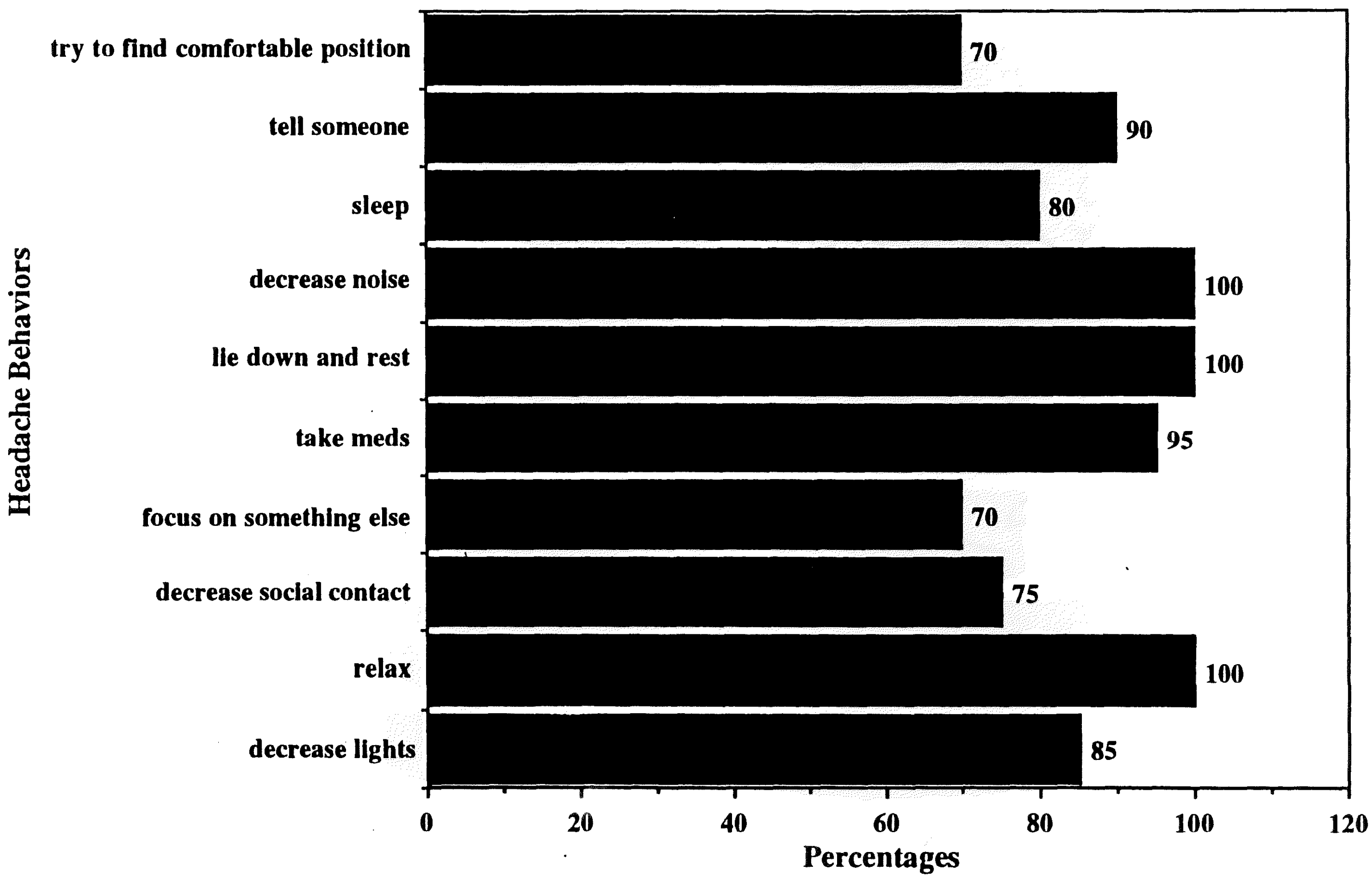


Figure 4

Frequencies of Selected Behaviors of Male Tension Headache Subjects

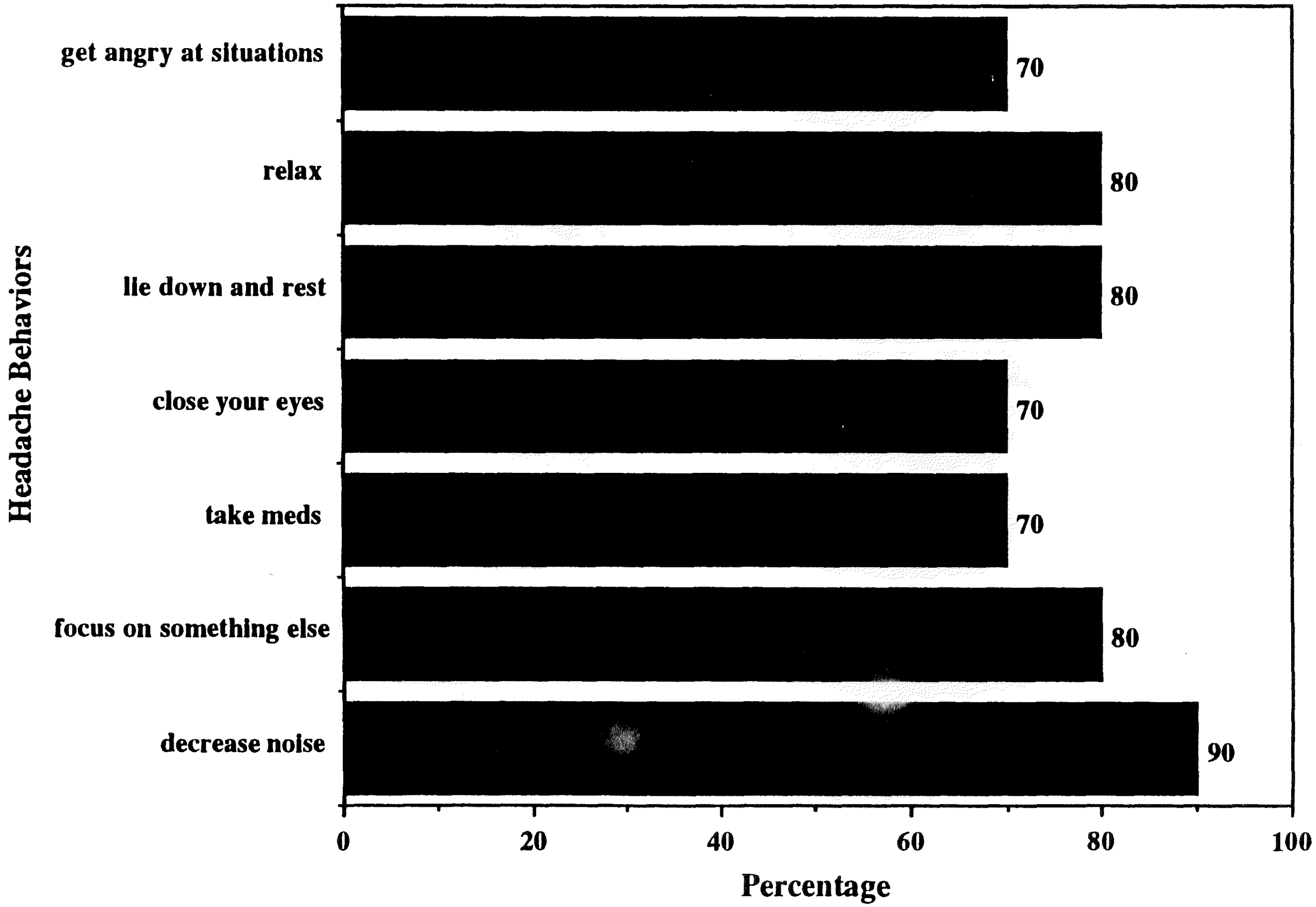
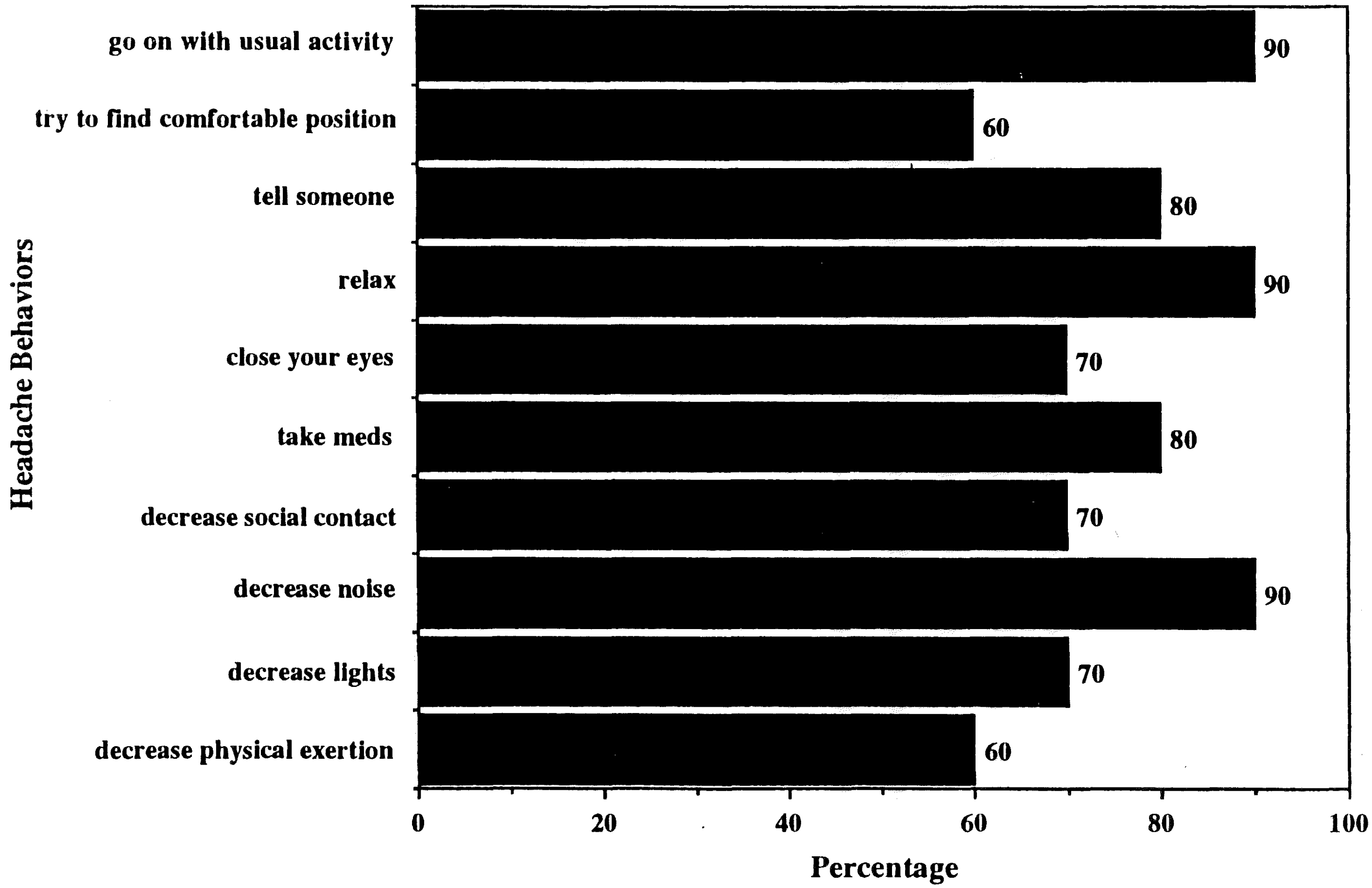


Figure 5

Frequencies of Selected Behaviors of Male Migraine Headache Subjects



differences between males and females in any of the three headache groups. Nor were any significant differences found between male tension, male migraine, and male control subjects or female tension, female migraine, and female controls subjects.

California Verbal Learning Test (CVLT). Several significant differences were found for the various subtests of the CVLT using ANCOVA. Analyses revealed significant main effects for gender for the first CVLT recall [F (1,83)=8.80, p=.004], the second CVLT recall [F (1,83)=10.17, p=.002], the third CVLT recall [F (1,83)=10.17, p=.002], and the CVLT long delay recall [F (1,83)=5.52, p=.02]. Table 2 contains the group means for each of these measures.

The test of parallelism was significant for the fourth CVLT recall [F (5,78)=2.73, p=.025]. ANCOVA then revealed a significant effect of BDI within headache status on this measure [F (3,78)=3.12, p=.031]. Correlations between the BDI and this measure for each of the headache groups can be found in Table 3. A significant main effect of gender was also found for this measure [F (1,78)=6.43, p=.013]. Table 2 contains the group means for this measure.

Table 2

Mean Scores for Significant Gender Effects

Test	Male	Female
CVLT 1	6.88	8.31
CVLT 2	9.96	11.57
CVLT 3	11.56	13.10
CVLT 4	12.86	13.80
CVLT 5	13.10	14.23
CVLT short delay	11.66	13.21
CVLT long delay	12.43	13.76
Tapping (dominant)	55.04	49.76

The test of parallelism was significant for the fifth CVLT recall [*F* (5,78)=3.86, *p*=.004]. Analyses showed that the covariate, BDI score, had a significant effect within headache status on this fifth recall of the CVLT [F (3,78)=6.14, p=.001]. Table 3 shows the correlations between this measure and the BDI for each of the three headache groups. A significant main effect of headache status was also found for this measure [*F* (2,78)=3.15, *p*=.048]. Tukey's post-hoc tests revealed a significant difference between tension (*M*=14.17) and migraine (*M*=13.3) headache subjects.

The test of parallelism was also significant for the CVLT long delay cued recall [*F* (5,78)=3.88, *p*=.033]. Individually calculated coefficients for the depression score regressed upon the measure showed a significant effect for BDI within headache status [*F* (3,78)=4.51, *p*=.006]. These correlation coefficients are shown in Table 3. After removing the effects of the covariate, a significant main effect for gender was found for the long delay cued recall [F (1,78)=9.67, p=.003]. Gender group means for this measure can be found in Table 2.

Finally, the test of parallelism was significant for the CVLT short-delay recall [*F* (5,78)=3.78, *p*=.004]. Further analyses, however, revealed no significant effect of the covariate on this measure. After removing the effect of the covariate, a significant main effect of gender [*F* (1,78)=8.91, *p*=.004] and a significant gender by headache

Figure 6

Gender by Headache Interaction for Stroop 1 Error Rate

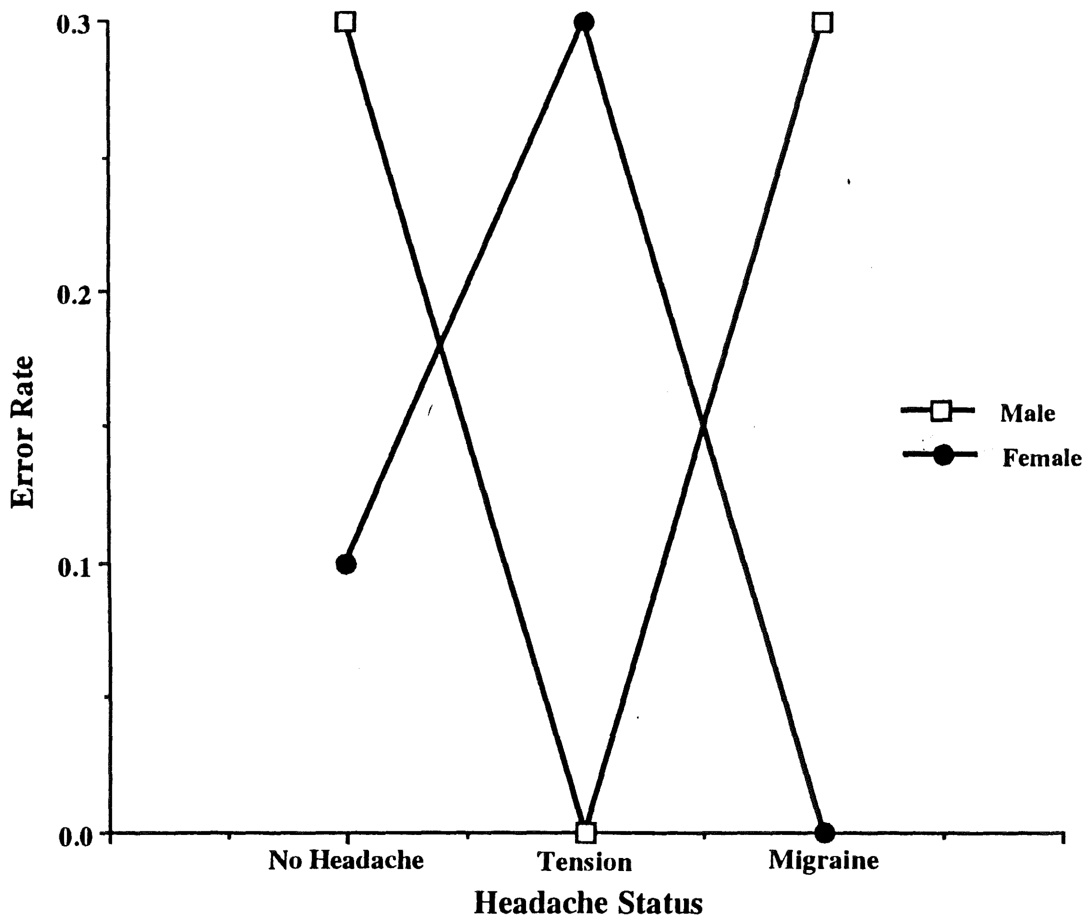


Table 3

Correlations Between BDI Score and CVLT4, CVLT5, CVLT Long Delay Cued Recall, WMS, and Four-Digit Sternberg Error Rate for BDI Within Headache Status Interactions

Group	CVLT4	CVLT5	CVLT-LD	WMS	STERN4
Control	-.27	-.50	-.46	-.34	.38
Tension	.20	.10	-.07	-.05	-.26
Migraine	.36	.26	.32	.21	-.35

status interaction were found [F (1,78)=8.91, p=.004]. Table 2 includes the gender group means on this measure. Tests of simple effects revealed significant differences between male and female control subjects [F (1,80)=12.41, p=.001] and male and female tension headache subjects [F (1,80)=7.34, p=.008]. In addition, tests of simple effects revealed a significant effect of headache status within females [F 1,78)=4.47, p=.014]. Tukey's post tests indicated that female controls (M=12.9) differed significantly from female tension headache subjects (M=13.9) on this measure (see Table 4). No other trials on the CVLT were found to have significant effects.

Table 4

Mean CVLT Short Delay Recall Scores for Gender by Headache Status Interaction

Group	Male	Female
Control	10.8	13.0
Tension	11.7	13.9

Simple Reaction Time Task. ANCOVA revealed a significant test of parallelism on this measure [F (5,78)=2.52, p=.036]. Individually calculated coefficients for depression (BDI) regressed upon this measure showed a significant effect of depression within gender by headache status [F (3,78)=5.94, p=.004]. Correlations between BDI scores and this measure were strongly negative for male migraine headache subjects and strongly positive for male control subjects, while female control subjects and female tension headache subjects showed slight negative correlations and female migraine headache subjects showed very slight positive correlations between the measures. These correlations are shown in Table 5.

Sternberg Task. A 2 (gender) by 3 (headache status) by 3 (trial) mixed design ANCOVA with two between-factors and one within-factor was performed on the three levels of the Sternberg test. ANCOVA revealed no

Table 5

Correlations Between BDI Score and WMS and SRT for BDI Within Headache by Gender Interactions

Group	WMS	SRT
Male Control	-.36	.60
Male Tension	.53	-.05
Male Migraine	-.12	-.48
Female Control	-.49	-.07
Female Tension	-.46	-.16
Female Migraine	.37	.06

significant effect of the covariate, no effect of headache status, no effect of gender, and no headache status by gender interaction.

ANCOVA did yield a significant main effect for trial on the Sternberg test [$F(2,83)=114.14$, $p=.000$]. Tests of simple effects indicated that there was a significant difference between Sternberg 2-digit trial and Sternberg 4-digit trial [$t(89) = 5.89$, $p=.000$], between Sternberg 2-digit trial and Sternberg 6-digit trial [$t(89) = 15.81$, $p=.000$], and between Sternberg 4-digit and Sternberg 6-digit trials [$t(89) = 9.58$, $p=.000$]. Means for Sternberg 2-digit, 4-digit, and 6-digit trials were 562.08, 665.22, and 874.84, respectively.

A series of 2 (gender) by 3 (headache status) ANCOVA were performed on the error rate data. The test of parallelism was significant for the number of errors committed on the four-digit Sternberg task [F $(5,78)=3.33$, $p=.009$]. ANCOVA revealed a significant effect of BDI within headache status for this measure [F $(3,78)=3.04$, $p=.034$]. The correlations between BDI and this measure were -.26 for tension headache subjects, -.35 for migraine headache subjects, and .38 for control subjects (see Table 3). No other significant effects were found on this measure.

ANCOVA also revealed a significant main effect for gender [F $(1,78)=4.54$, $p=.036$] and significant gender by headache status interaction [F $(2,78)=3.66$, $p=.030$] for the number of errors made on the six-digit Sternberg task. Subsequent tests of simple effects revealed a significant difference [F $(1,83)=9.91$, $p=.002$] between male and female control subjects (see Table 6).

Table 6

Mean Number of Errors for Six-Digit Sternberg Gender by Headache Status Interaction

Group	Male	Female
Control	1.02	2.28

Trail-Making Test. The test of parallelism was significant for the Trail-Making Test's A-to-B ratio [F (5,78)=3.05, p=.014]. ANCOVA also yielded a significant effect for the covariate, BDI score, within gender [F (1,78)=7.64, p=.007]. The correlation coefficients of the covariate, BDI, within the A-to-B ratio were found to be -.28 for males and .22 for females. ANCOVA revealed no further significant effects.

Chi-Square Analyses.

Chi-square analyses were conducted on all neuropsychological data to determine the distribution of impairment for each of the groups. Standardized norms were used to classify subjects into categories of "impaired" and "not impaired" (Revised Lafayette Clinic Adult Neuropsychological Battery Norms, 1977; Robinson, Heaton, Lehman, & Stilson, 1980; Wechsler, 1945). Finally, the numbers of subjects scoring in the impaired range on each test were compared across the three headache status groups.

Headache-Free Control Subjects. Chi-square analyses revealed a greater than expected number of control subjects in the impaired range on three measures from the California Verbal Learning Test (CVLT). Those measures were CVLT-recall 1 [x^2(1, N = 30) = 107.37, p=.000], CVLT-recall 2 [x^2(1, N = 30) = 13.333, p=.000], and CVLT-short delay recall [x^2(1, N = 30) = 13.333, p=.000]. In addition, a greater number than expected of the headache-free controls also scored in the impaired range on number of errors committed on the WCST (x^2(1, N = 30) = 5.926, p=.015], and WMS logical memory (x^2(1, N = 30) = 18.148, p=.000].

Tension Headache Subjects. A greater number than expected of tension headache subjects scored in the impaired range on five of the CVLT scales including CVLT-recall 1 [x^2(1, N = 30) = 47.040, p=.000], CVLT-recall 2 [x^2(1, N = 30) = 13.333, p=.000], CVLT- short delay [x^2(1, N = 30) = 13.333, p=.000], CVLT-long delay [x^2(1, N = 30) = 13.333, p=.000], and CVLT-long delay cued recall [x^2(1, N = 30) = 5.926, p=.015]. A greater number of the tension headache subjects than expected also scored in the impaired range on WMS Logical Memory subtest [x^2(1, N = 30) = 13.333, p=.000], WCST total errors [x^2(1, N = 30) = 5.926, p=.015], WCST total number of categories completed [x^2(1, N = 30) = 5.926, p=.015] and Trail Making A-to-B ratio [x^2(1, N = 30) = 30.000, p=.000].

Migraine Headache Subjects. A greater than expected number of migraine headache subjects scored in the impaired range in six CVLT measures including CVLT-recall 1 [x^2(1, N = 30) = 83.333, p=.000], CVLT-recall 2 [x^2(1, N = 30) = 5.926, p=.015], CVLT-recall 3 [x^2(1, N = 30) = 13.333, p=.000], CVLT-recall 4 [x^2(1, N = 30) = 9.259, p=.002], CVLT-recall 5 [x^2(1, N = 30) = 18.148, p=.000], and CVLT-short delay [x^2(1, N = 30) = 30.000, p=.000]. In addition, a greater than expected number of migraine headache subjects scored in the impaired range on two WMS subtests: WMS digits recalled [x^2(1, N = 30) = 5.926, p=.015] and WMS Logical Memory [x^2(1, N = 30) = 30.000, p=.000]. A greater number of migraine headache subjects than expected scored in the impaired range on two WCST subtests: the number of errors committed [x^2(1, N = 30) = 9.259, p=.002], and the total number of categories completed [x^2(1, N = 30) = 5.926, p=.015]. Finally, a greater than expected number of migraine headache subjects scored in the impaired range on Trails A-to-B ratio [x^2(1, N = 30) = 44.815, p=.000].

Comparisons among migraine, tension and control subjects. Chi-square analyses of neuropsychological data between groups revealed no significant differences between the groups in terms of the proportion of group members that scored in the impaired range.

CHAPTER IV

DISCUSSION

The present study was designed to examine possible neuropsychological deficits in migraine and tension headache subjects. Past research has been inconclusive, with some studies indicating that chronic migraine headache sufferers do exhibit some neuropsychological deficits such as short-term memory difficulties, gross motor slowing, and verbal memory deficits (Covelli, Antonaci, & Puca, 1984; Hooker & Raskin, 1986; Schucman & Thetford, 1970; Zeitlan & Oddy, 1984), while other studies have indicated that no deficits are seen in this group (Leijdekker, et al., 1990). Also examined were headache precipitant and headache-related behaviors that these groups partake in when experiencing headache pain. Past research has suggested that migraine headache sufferers tend to deal with their headache pain differently than tension headache sufferers (Lamberty, Holm, Ehde, and Plevell, 1989).

Headache Precipitant and Behavior

Analysis of headache precipitant and headache behavior questionnaires revealed that tension and migraine headache sufferers consistently attributed headache activity to stress, too much/little sleep, strong odors, and glare or bright lights. Migraine patients tended to try more behavioral techniques to decrease headache pain, which is not surprising considering the fact that migraine headache pain is seen as more debilitating than tension headache pain. Both male and female migraine headache sufferers reported attempting to decrease outside stimuli along with taking medication and trying to relax. There appeared to be little difference between how male and female migraineurs coped with their pain. On the other hand, male and female tension headache sufferers reported some similar but also some different coping strategies. While both reported that they frequently take medication and decrease outside stimuli, male tension headache sufferers reported that they get angry because of headache pain and try to focus on other things while female tension headache sufferers indicated that they are more likely to cope by confiding in others and seeking their support.

These data indicate that studies addressing sufferers coping behaviors should consider the importance of gender differences, especially in tension headache sufferers. Gender may be an important factor to consider when attempting to understand the manner in which an individual copes with headache pain. Of course, it is certainly possible that gender is not the ultimate cause of the apparent "gender differences", but rather these differences may reflect sex role socialization or some other learned process.

Neuropsychological Tests

When all of the neuropsychological tests of the battery were given equal weight, the three groups did not differ significantly in the percentage of tests performed in the impaired range. However, a number of individual tests did significantly differentiate the subject groups.

Shipley Institute of Living Scale. Intellectual level, as measured by the Shipley, was not significantly different for the three groups. The covariate, BDI, was found to have no effect on this measure, and no chi-square analyses were significant. This finding is consistent with literature that states that the intellectual functioning of chronic headache sufferers is within normal limits and not significantly different from that of non-headache sufferers (Leijdekker, et al., 1990).

Wechsler Memory Scale. The majority of the analyses pertaining to the effect of depression on the WMS subscales indicated that depression did not have a significant effect on subject's subscale scores. However, depression did have an effect on the overall WMS score. Male migraine headache sufferers, female tension headache sufferers, and both male and female control subjects exhibited a negative correlation between BDI score and overall WMS performance while male tension headache sufferers and female migraine headache sufferers exhibited positive correlations between the two variables. After removing the effect of the covariate, the only significant effect of headache status or gender was an interaction found on the WMS in which male tension headache sufferers scored slightly lower than female tension headache sufferers. None of the other subscales of the WMS had significant ANCOVAs. Chi-square analyses of the other subscales revealed a significant number of impaired subjects on the Logical Memory, Digit Span, and Visual Reproduction subscales of the WMS, with > 20% of subjects in each group scoring in the impaired range. All other subscales of the WMS were within normal limits for all three groups. Chi-square analyses between the three groups found no significant differences in the proportion of subjects scoring in the impaired range on the WMS.

The correlation between depression and WMS score seen among both male and female control subjects, female tension headache sufferers, and to a lesser extent male migraine sufferers, is in the expected direction (i.e., the more depressed an individual becomes, the lower his/her overall cognitive functioning becomes). However, the positive correlation that is noted for the female migraine headache sufferers and the male tension headache sufferers was not expected. Both groups clearly show a positive correlation between increased depression and cognitive efficiency.

It has been noted in the literature that depression can have the overall effect of lowering an individual's ability to attend and concentrate, thus lowering overall memory functioning (Lezak, 1983). This is clearly the case for the control subjects, the male migraine subjects, and the female tension headache subjects, but not so for the other two groups. Weingartner et al. (1981) propose that an individual's level of depression has the overall effect of lowering cognitive functioning and that disruptions in arousal-activation in depression can account for these cognitive impairments. Perhaps male tension headache sufferers and female migraine sufferers have become so accustomed to working during increased levels of depression that they have become quite adept at it. However, it would seem likely that there would come a point that this level would plateau, and overall cognitive functioning would begin to decrease. Also, this does not explain why female tension and male migraine subjects show the expected pattern of findings.

The significant headache by gender interaction revealing a difference between male and female tension headache sufferers on the WMS was the only significnat effect of either headache status or gender on the WMS. or any of its subscales. This effect revealed that male tension headache sufferers score significantly lower on the WMS than females. This has not been reported previously in headache literature or research in the general population (Lezak, 1983). Although this is an interesting finding, unless it can be replicated, few conclusions can be drawn.

Inspection of the Chi-square analyses revealed a startling number of subjects from each group scoring in the impaired range on the WMS, but failed to show any significant groups differences.

Impairment of logical memory and digit span in migraine headache sufferers has been reported in the literature (Covelli et al., 1984; Shucman & Thetford, 1970; Zeitland & Oddy, 1984). However, the same has not been reported in the literature for tension headache sufferers. In the current sample, tension headache sufferers were as likely as migraineurs to score in the impaired range.

Interestingly, though most of the groups did show an overall drop in WMS score as a result of depression, there were no statistically significant effects of depression found in any of the individual subscales. Perhaps the overall deficit is a composite of small, but not statistically significant deficits on many of the subscales. This would not be inconsistent with the literature, though significant differences would be expected on the Digit Span, Associate Learning, and Visual Reproduction subscales (Lezak, 1983). It is difficult to say why male tension headache sufferers and female migraine headache sufferers do not experience the same effect form depression that the other groups do. It is also puzzling that the tension headache sufferers and control subjects would have such a large number of subjects scoring in the impaired range. Motivation may play a role in the individual's performance on this task. Replication of this finding with a larger number of subjects, specifically male subjects, may lend more credence to these results.

Finger Tapping Test. There was no effect of the covariate, depression, noted for finger tapping speed. A significant gender effect was noted for the finger tapping speed, with males performing significantly better than females. No chi-square analyses were significant for this test.

The gender difference that is seen is not an unusual finding and is consistent with standardized norms (Lewis and Kupke, 1977). Males generally score approximately 10% higher than females on this task. However, it is unusual that this same pattern of performance would not be found for the nondominant hand. Also inconsistent with prior research is that no effect was seen for the covariate, depression. Prior literature indicates that depression has the effect of increasing fine motor response time in individuals experiencing moderate to severe levels of depression (Weingartner et al., 1981).

The effect of depression, as indicated above, is to slow an individuals motor response. The fact that this effect is not seen for these groups may indicate that the level of depression seen by subjects is not at a severe enough level to affect motor responding. Another possible explanation is that at the time that the Lafayette norms were developed, hand-eye coordination, in the traditional sense, was considered a "typical" male characteristic. In recent years, with the advent of video games and increasing encouragement that females have received to get involved in "male" activities, perhaps the gender differences that were commonplace in the early 1970s have decreased or no longer exist. Replication with a larger sample size would also be necessary to lend credence to this finding.

Stroop Test. There was no significant effect of the covariate found for the Stroop task. There were also no significant group differences found in the ability to shift perceptual set and conform to changing demands, as measured by the Stroop Test. However, analysis of neuropsychological test data indicated a significant gender by headache status interaction for the number of errors committed on the first Stroop trial. Though subsequent tests of simple effects failed to find significant effects for either gender or headache status, inspection of the data indicates that female tension headache made more errors than the other two groups of female subjects while male controls and migraine headache sufferers made more errors than male tension headache sufferers (see Figure 6).

Past research with headache sufferers has not used this task, though it is thought to be helpful in the localization of brain dysfunction, specifically frontal lobe dysfunction. It was added to the present study's test battery for that particular purpose. Past research has indicated that perhaps some of the difficulties that are noted with verbal fluency and general information processing can be localized to the frontal regions (Zeitlan & Oddy, 1984). These difficulties are not seen in the current study. There are at least two possible explanations for this finding. First, once again, it is possible that motivation plays a large part in the subjects' performance on this task. It is a relatively short and simple task, and as a result, most subjects seemed to attend fairly easily to the task. Second, it may be that the Stroop test actually measures different processes than those that others have proposed to assess frontal dysfunction. At any rate, the groups all performed well on this test.

California Verbal Learning Test. ANCOVA revealed a significant effect of BDI within headache status for CVLT 4, CVLT 5, and Long Delay. The correlations between these scales and BDI score were generally negative for the control group, but positive for both headache groups. The control subjects score in the way that would be expected, (ie., as level of depression increases, performance decreases), while the headache groups scored in the opposite direction. ANCOVA revealed significant gender effects for CVLT 1, CVLT 2, CVLT 3, CVLT 4, CVLT5, CVLT short delay, and CVLT long delay recall trials, with males recalling significantly fewer words on each of the above tasks. A significant gender by headache status interaction was found for short delay recall and tests of simple effects revealed significant differences between male and female control subjects and male and female tension headache subjects. In addition, tests of simple effects revealed a significant effect of headache status within females, with female controls scoring significantly lower than female tension headache subjects. A significant main effect for headache was also found for CVLT 5. Post-hoc tests revealed significant differences between tension and migraine headache subjects with tension headache subjects scoring higher than migraine headache subjects on this measure. After removing the effect of BDI, a significant main effect for gender was found. As previously noted, males scored significantly lower on this measure than females. Chi-square analyses revealed a significantly greater than expected number of subjects scoring in the impaired range of the CVLT for many of the trials. All three groups had a significant number of subjects scoring in the impaired range on CVLT1 and CVLT2, though only migraine headache sufferers scored in the impaired range on CVLT3, 4, 5, and long delay recall. Chi-square analyses between the three groups did not differ in the number of subjects that scored in the impaired range.

As stated previously, depression generally has a negative effect upon an individual's memory capacity (Weingartner et al., 1981), though this does not seem to be the case with all subjects from the current study. While control subjects tended to respond to depression in the manner that would be expected, both tension and migraine headache sufferers showed the opposite pattern of response, though the difference was much more pronounced in migraine sufferers than in the tension headache group.

Effects of depression aside, there were also a considerable number of gender effects on this task. These gender differences are expected and reported in the CVLT norms (Delis, Kramer, Kaplan, & Ober, 1987). Females consistently scored 1.5 words higher on these trials than males. While these effects are expected, the scores achieved by the current sample are consistently 1-2 points lower than that expected for both males and females in a normal population. Chi-square analyses revealed that migraine headache sufferers had a greater number of subjects than expected scoring in the impaired range for CVLT 3, 4, and 5 which would seem to indicate that migraine sufferers begin by recalling approximately the same number of words that the other two groups recall, though they are not able to learn consistently more words in repeated trials. This type of performance is consistent with difficulty in concentration and inattention (Lezak, 1983). It should be noted that when chi-square analyses between the three groups were computed, the groups did not differ significantly in the proportion of subjects scoring in the impaired range.

As seen previously, control subjects show correlations for BDI score and memory measures that are in the direction that would be expected given prior research. On these measures, migraine headache sufferers consistently showed the reverse correlation of what would be expected. The BDI scores for the migraine group are significantly higher than those of the other two groups, though they are not in clinically significant range for depression. It is unlikely that the mild to moderate levels of depression reported by migraine headache subjects would lead to this level of short-term memory difficulty. It should be noted that none of the three groups had high enough depression scores to score in the clinically depressed range. As mentioned previously, there remains the possibility that those who experience frequent headaches have adapted to this pain and accompanying depression, and as a result, perform at or slightly above a normal level while experiencing pain and accompanying depression. A significant number of migraine headache sufferers showed some impairment in short-term memory as measured by the CVLT. Although the other two groups also showed some deficits on this scale, the controls and tension headache sufferers were able to improve their scores with repeated trials. The migraine headache sufferers had difficulty improving their scores with repeated trials and were unable to learn the appropriate amount of material over five trials. Inability to maintain initially encoded material is often indicative of problems with consolidating memory into longer-term storage. Posterior regions of the left temporal cortex appear to be involved in the retrieval of information from storage (Lezak) and may be affected in migraine patients.

<u>Sternberg Task</u>. The 2 (gender) by 3 (headache status) by 3 (trial) ANCOVA revealed a significant main effect for trial, indicating that individuals required a significantly longer period of time to respond as set size increased. This effect is expected.

The majority of analyses pertaining to the effects of depression on the Sternberg task indicated that level of depression has no effect on performance of this task. However, depression was seen to have an effect on headache status and the number of errors committed on the four-digit Sternberg task, with controls showing a positive correlation between the two factors and both headache groups displaying a negative correlation. A significant main effect of gender for errors committed on STERN 6 revealed that males made significantly more errors on this task than females (3.12 and 1.29, respectively). The gender by headache status interaction seen for errors committed on STERN 6 was analyzed and revealed a simple effect for gender in control subjects with female control subjects making significantly fewer errors than male controls (1.02 and 2.28, respectively). No chi-square analyses were significant for this measure.

Once again, depression has the expected effect for control subjects (i.e., as depression increases, so do errors), while both headache groups show the opposite correlation. Research would suggest that increased levels of depression should increase an individuals reaction time, though not necessarily the number of errors committed on a task (Lezak, 1983). Depression aside, past research has indicated that migraine headache sufferers exhibit slower choice reaction times than controls and have less dexterity. It is unclear from the literature as to exactly why this occurs. Others have reported no deficits in reaction time for migraine patients (Covelli et al., 1984; Leijdekker et al., 1990; Schucman & Thetford, 1970).

Lezak (1983) suggests that choice reaction time is particularly useful in delineating organic disorders, yet it remains virtually unchanged in most individuals until well into the 6th or 7th decade of life. Therefore, it would seem unlikely that this would be effected in the current sample unless they displayed some gross organic dysfunction.

Simple Reaction Time. Analyses revealed a significant effect of the covariate, depression, within gender. Correlation coefficients between BDI score and SRT reveal that male controls display a strong positive correlation (.60) between BDI score and reaction time and male migraine subjects display a strong negative correlation. Correlations for other groups are fairly weak, and generally in the negative direction (see Table 5). None of the chi-square analyses were significant for this task.

Male controls displayed the expected correlation with depression, i.e., as depression increases, so does simple reaction time. As mentioned above, Zeitlan and Oddy (1984) and Hooker and Raskin (1986) both reported slower reaction times in their groups of migraine headache patients, though this was clearly not the case with the current sample.

Trail-Making Test. Analyses revealed a significant effect of the covariate within gender. Correlation coefficients for Trail A-to-B ratio (TRAILR) and BDI score revealed a negative correlation for males (-.24) and a positive correlation for females (.22). Also, chi-square revealed that a significant number of subjects from all three groups scored in the impaired range for the Trail Making Test A-to-B ratio.

The female subjects display the pattern that would be expected, with Trail B score increasing as level of depression increases. Interestingly, over half of the female migraine sufferers (11 of 20 subjects) scored in the impaired range while only 2 of the male migraine subjects scored in this range. The TMT is a test of visual motor tracking with Trail B being a test of higher order processing, and gender differences are not expected on this task. Zeitlan and Oddy (1984) reported that migraine headache sufferers exhibited less efficient information processing than controls, though others have failed to find this same deficit (Covelli et al., 1984; Hooker & Raskin, 1986; Leijdekker et al., 1990; Schucman & Thetford, 1970). The current study clearly supports the latter research that no differences exist.

Wisconsin Card Sorting Test. ANCOVA revealed no significant differences between groups for the Wisconsin Card Sorting Test. Nor was the effect of the covariate significant. Although most WCST scales were unimpaired, all three groups had a significant number of subjects that scored in the impaired range on the WCST total error rate. A significant number of tension headache sufferers and migraine headache sufferers also scored in the impaired range for the total number of categories completed on this task. There were no significant chi-square analyses between groups.

This test has not been specifically used in previous studies involving headache subjects, though it does assess higher order functioning and processing abilities much like other tests that were used in previous research (Hooker & Raskin, 1986; Zeitlan & Oddy, 1984). Zeitlan & Oddy (1984) found less efficient information processing among migraine headache patients on similar tasks, though Hooker and Raskin failed to find these same problems. The current study failed to find the difficulty in processing that had been reported. The subjects in this study performed quite well on this task. Although the experimental groups had a significant number of subjects scoring in the impaired range for the number of categories completed, the numbers were only slightly greater than that expected in the general population.

This lack of significant deficits on the Wisconsin Card Sorting Test would seem to indicate that executive functioning and reasoning abilities are not affected by migraine headache. Though a significantly greater number of subjects than expected did score in the impaired range for number of categories completed, there were no significant group differences.

Limitations and Conclusions

Results from the headache questionnaires showed that although headache sufferers tended to attribute their headache development to many of the same precipitants, their ways of dealing with their headache pain varied considerably. While migraine headache sufferers tended to use behavioral techniques to decrease/minimize their headache pain, tension headache sufferers frequently reported getting angry with the situation and telling others about their pain. Migraine headache sufferers rarely reported dealing with their headache pain by becoming angry or telling others. One possible reason for the differences in the way the two groups address their headache pain may be largely related to the type of pain that they experience. Tension headache sufferers, as a rule, experience headaches more frequently, and generally with less intense pain than migraine headache sufferers. Interestingly, although both groups of headache sufferers believed that stress played a large role in their development of headache pain, migraine sufferers reported trying to reduce this stress and tension. The male tension headache sufferers did something that may be viewed as feeding into this tension, i.e., they became upset with the situation.

It is also important to look at gender differences in coping behaviors. Male and female tension headache sufferers tended to take different approaches to dealing with headache pain. Tension headache sufferers reported telling others about their headache pain, while neither male groups reported doing this with any great frequency. As stated previously, this may be a result of societal sex roles in which it is acceptable for females to express that they are in pain, while this is not traditionally considered "appropriate" for males.

Overall, when looking at the significant effects that involve the covariate, depression, a striking difference is generally noted between the control subjects and the migraine headache subjects, with control subjects generally scoring in the direction that would be expected (i.e., as level of depression increases, so does degree of impairment) and migraine headache sufferers scoring in the opposite direction. Generally, individuals who experience chronic pain tend to report higher levels of depression than those who do not experience chronic pain. If migraine headache pain is viewed as a form of chronic pain, one possible explanation for the pattern of results seen with migraine headache patients may be that they tend to have to go on with life and operate effectively, regardless of the level of pain and depression that they are experiencing. Perhaps they have become so effective in compensating for the level of pain/depression, that they become hyper-attentive and actually perform better when experiencing migraine-related depression or pain. On the other hand, when the migraine headache sufferer is experiencing lower levels of depression or pain, s/he may be less focused and attentive. Results from the questionnaires given in this study suggest that migraine headache sufferers tend to do more behavioral acts to get rid of or to minimize their pain. With continued operation under these types of conditions, they may become better than others at functioning when they are experiencing pain or depression. In the present study, depression appeared to play a larger part in subjects performance than headache status played.

With the exception of performance on the CVLT, the migraine headache sufferers did not perform significantly different than the other two groups. In fact, they performed somewhat better on some tasks such as immediate visual reproduction and number of errors on the WCST. Studies have indicated that there is a significant relationship between length of migraine history and degree of neuropsychological impairment (Steiner et al., 1980; Whitty & Hockaday, 1968). Perhaps with the relatively short period of time that these subjects had been experiencing migraine headaches, neuropsychological impairment is not yet clinically significant. There is also the research that indicates regardless of a patient's length of migraine history, no significant neuropsychological impairment is noted (Leijdekker et al., 1990). In the present study, there does appear to be some small degree of impairment in short-term memory in migraine headache sufferers, which would support the former line of research. However, this degree of impairment was not statistically significant when analyzed across groups. After removing the effects of depression, few statistically significant differences were noted between groups on these short-term memory tasks.

The many gender differences that were found among subjects were not particularly unusual since, with the exception of the Sternberg Task, these differences have been reported in normative data and are actually expected. The one unusual finding is that females did not differ significantly from males in nondominant tapping performance. Generally there should be approximately a 10% difference between these two groups (Lewis & Kupke, 1977).

Perhaps the most unexpected finding of the study is the fact that all three groups showed significant neuropsychological impairment in many areas, although the groups did not differ significantly from each other in the proportion of subjects that scored in the impaired range. One possible explanation for this effect may be due to the fact that all subjects were volunteers, and may not have worked as diligently as they were capable. Also, anxiety is known to have a deleterious effect on performance of all subjects (Lezak, 1983). It could be that with these high functioning individuals, there was great anxiety to perform extremely well, and as a result, their anxiety levels caused them to perform more poorly than they normally would. Due to the relatively small number of subjects in the study (especially male subjects), it would be important to replicate the findings before drawing firm conclusions. finally, it should be noted that all of the past studies in this area have utilized patient populations rather than college students. It is highly likely that the subjects from the current study do not experience as severe headaches as those in previous studies. Although many of the migraine headache sufferers in the current study report having seen a physician for their headaches, none of the subjects reported taking prescription medication for their headache pain.

It was hypothesized that perhaps the neuropsychological deficits that were seen in prior studies may be largely due to the age of the patients that were used for the studies (i.e., a cumulative effect model). In other words, the neuropsychological impairment seen may have been a result of repeated migraine attacks, the aging process itself, a long history of medication use, or any combination of these factors. In the present study, a very young population with a relatively short history of migraine headache and no prescription medication use, was used in order to look at these issues. A relative lack of impairment was seen for the migraine group on all tasks. Migraine sufferers performed as well, if not better than other groups on all tasks. When depressed, the migraine sufferers, as a group actually performed better than the other groups on many of the tasks. There does not seem to be impairment with the migraine headache as reported in previous studies. Perhaps those deficits that have been noted in previous studies are age-related changes or changes due to the cumulative effects of age, medication use, and repeated migraine attacks.

In conclusion, this investigation challenges the assumption that migraine headache causes permanent neuropsychological changes. Once the effects of depression had been factored out, the present study found no significant differences between migraine headache sufferers and the other groups. In fact, the migraine headache sufferers showed a tendency to perform better than the other groups while experiencing depression. It remains puzzling as to exactly why this is the case and findings certainly require replication. Future neuropsychological investigations of migraine conducted longitudinally would be helpful in delineating the neuropsychological changes that may or may not occur in migraine headache sufferers.

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