QEEG AND MMPI-2 PROFILES OF ADULTS REPORTING CHILDHOOD SEXUAL
ABUSE: DETERMINING DIFFERENCES AND PREDICTOR MODELS

Alicia L. Townsend, B.A.

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APPROVED:
Eugenia M. Bodenhamer-Davis, Committee Chair,
Dissertation Major Professor
Jerry C. McGill, Committee Member, Academic
Major Professor
Ernest Harrell, Committee Member
Frances McManemin, Committee Member
Linda L. Marshall, Chair of the Department of
Psychology
Joseph A. Doster, Program Coordinator for Clinical
Psychology Program in Health Psychology and
Behavioral Medicine
Sandra L. Terrell, Interim Dean of the Robert B. Toulouse
School of Graduate Studies
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Childhood sexual abuse (CSA) has been linked to a number of adult psychological maladies. The MMPI-2 has shown specific patterns such as an inverted V in the validity scales, a floating profile, and a 4-5-6 configuration to be present more often in adults who have experienced childhood trauma. Both children and adults who have experienced trauma have shown a number of neurophysiological differences when compared to non-traumatized individuals. However, little research has looked at differences in quantitative electroencephalography (QEEG) patterns in these individuals. The purpose of this study is to determine differences seen in the MMPI-2 and the QEEG when comparing adults who report CSA to adults who deny any history of childhood abuse. Differences between the two groups in MMPI-2 basic scales and supplementary scales PK and PS were determined. This study also examined the ability to correctly classify individuals into the two groups using three patterns seen in the MMPI-2 basic scale profiles (inverted V, floating profile, and 4-5-6 configuration). In addition, this research included exploratory analyses to develop predictor models for CSA group membership. Predictors in the models were derived from MMPI-2 scales, alpha relative power at each of the 19 sites in the International 10/20 electrode placement system, as well as alpha/delta, alpha/theta, and alpha/beta ratios at each of the 19 sites. A total of 46 participants were included in this study, 24 from archived files and 22 newly recruited individuals. Each participant received a MMPI-2 and a QEEG. Significant differences were found between the MMPI-2 scores of the two groups, but MMPI-2 patterns were unable to correctly classify individuals. Models were found which were clinically relevant and statistically significant. The models were
based on depression and social maladjustment. The depression models included scales F and 2 of the MMPI-2 and alpha relative power at left frontal sites. The social maladjustment models included scales 4 and 8 of the MMPI-2 and alpha relative power at temporal sites. These findings support previous research showing higher levels of pathology in MMPI-2 profiles and evidence for temporal and left-frontal differences in adults who report CSA.
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INTRODUCTION

Prevalence rates of childhood sexual abuse among adults have been estimated to be between 15 to 32% in females and 7.2 to 8.5% in males (Gorey & Leslie, 1997; Vogeltanz, Wilsnack, Harris, Wilsnack, Wonderlich, & Kristjanson, 1999). However, this is likely to be an underestimate, as it is believed that many cases go unreported. Both the psychological and physiological effects of childhood trauma are evident. A history of childhood sexual abuse (CSA) has been shown to be associated with a number of adulthood maladies such as depression, anxiety, poor self-esteem, self-destructive behavior, feelings of isolation and stigma, revictimization, sexual dysfunction, substance abuse, and suicidal ideation and attempts (Beitchman, Zucker, Hood, DaCosta, Akman, & Cassavia, 1992; Briere & Elliott, 1997; Browne & Finkelhor, 1986). A high number of sexually abused individuals also appear in populations of those suffering from dissociation (Bowman & Markand, 1996; Coons, 1992; Coons, Bowman, & Milstein, 1988), post-traumatic stress disorder (PTSD; Bowman & Markand, 1996), chemical dependence (Clay, Olsheski, & Clay, 2000; Heffernan, Cloitre, Tardiff, Marzuk, Portera, & Leon, 2001) eating disorders (Rastam, 1994), seizure disorder (Bowman, 1993; Bowman & Markand, 1996; Devnesky, Putnam, Grafman, Bromfield, and Theodore, 1989), psychogenic amnesia (Coons & Milstein, 1992), headaches (Domino & Haber, 1987), and criminality (Blake, Pincus, & Buckner, 1994).

Research has investigated personality profiles of adults with a history of CSA using both the original Minnesota Multiphasic Personality Inventory™ (MMPI) and the revised version (MMPI-2). Adults with a history of CSA have shown significantly more pathology on these instruments when compared to non-abused adults. Findings have shown three basic profile patterns with CSA groups: 1) a high F scale in relation to scales L and K yielding an inverted V
in the validity scales, 2) floating profiles with six or more basic scales elevated, and 3) a 4-5-6 configuration, formerly known as the Scarlett O'Hara V, in which scales 4 and 6 are above a T score of 65 and scale 5 is 35 or below. Some studies also have shown clusters of different types of profiles of sexually abused individuals, and attempts have been made to develop a sexual abuse scale using current MMPI-2 questions. This research is summarized below.

Within psychiatric inpatient groups with a history of sexual abuse, Carlin and Ward (1992) discovered four clusters of MMPI profiles. Means for the first cluster showed a valid profile with no significant elevations of the basic scales. Cluster two means showed an excessively high F scale (T score = 94.46) resulting in an inverted V in the validity scales, and a floating profile with elevation of all basic scales except 5 and 9, with 8 being the highest in elevation. Cluster three means showed a similar yet less extreme pattern with a floating profile with elevations on all basic scales except 5, 9, and 0. Scale 2 was the highest elevated scale for cluster three. Cluster four means showed another high T score value for the F scale ($M = 75.7$) yielding the inverted V, with elevations on the basic scales of 2, 4, 6, 7 and 8. Cluster four means had five elevated basic scales, one short of the six elevations needed to qualify as a floating profile.

Similarly, Belkin, Greene, Rodrigue, and Boggs (1994) also found a four-cluster model. However, they included abused and non-abused individuals together in the cluster analysis. Means of their first cluster, similar to that of Carlin and Ward, showed a valid profile with no significant elevations on the basic scales. The first cluster contained 17.1% of the total abused group. Means of their second cluster showed a spike 8-4 with significant elevations on scales F, 2, 4, 6, 7, and 8, thus showing an inverted V in the validity scales, but not qualifying as a floating profile. Most of the abused group (50.5%) were members of this second cluster. The third cluster
means showed a spike 2-3 with significant elevations on scales 1, 2, and 3. This cluster contained 28.6% of the abused group. The fourth cluster means showed significantly high L and K scales, indicating a defensive test taking style. These individuals had no significant elevations, perhaps due to an attempt to present themselves in a better light. Only 3.8% of the total abused group had profiles that fit into this cluster. Belkin and his colleagues also reported that abused individuals were significantly higher than non-abused individuals on scales F, 4, 6, 7, 8, 9, and 0. They found that males differed significantly from females on scales 5 and 9.

Goldwater and Duffy (1990) showed that female psychiatric patients with a history of childhood sexual abuse could be identified by an MMPI 4-5-6 configuration, with the T score of scale 5 being at least 30 points lower than scales 4 and 5. Their definition was a variation of the Scarlett O'Hara V, which is identified as scale 5 being below a T score of 35 and scales 4 and 6 being above a T score of 65. Goldwater and Duffy noted that scales F, 2, and 8 were likely to be elevated in this population, as well.

Hunter (1991) included males and females in his non-clinical sample. He found that males showed greater psychopathology compared to controls on the scales F, K, 1, 2, 3, 4, 6, 7, and 8. These males also scored at least two standard deviations above the mean on scales 4, 5, 7, and 8. Females with a history of childhood sexual abuse showed greater pathology than controls on scales F, K, 1, 2, 3, 4, 6, 7, 8, 9, and 0. These females scored at least two standard deviations above the mean on scales 4 and 8. Hunter concluded that males may experience more anxiety, worry, and rumination as compared to females, especially concerning identity issues and conflicts.

In a study of 31 adult outpatient females who had been molested by either their father or stepfather, Scott and Stone (1986) found significant elevations on scales 4 and 8. This adult
group was also compared to an adolescent group of outpatient females with a history of CSA to whom the MMPI had been administered. They found that adult abused females scored significantly higher on all scales but L, K, and 5 when compared to adolescent abused females. The adult abused group scored significantly lower on scale K. These findings suggest a possible increase in pathology and decrease in defensiveness with age.

Although consistent patterns have been seen in the MMPI of adults with a history of CSA, short forms of the MMPI have shown different results. Engels, Moisan, and Harris found adult female outpatients with a history of CSA often showed a 4-8 profile or a 2 spike on the less lengthy R-form of the MMPI. They also found higher F scales in comparison to non-abused individuals. They reported finding a number of floating profiles as well as profiles with an F-K index of 15 or more. Valliant, Maksymchuk, and Antonowicz (1995) used the shortened MMPI Form 168 to compare incarcerated females with a history of CSA to two groups of female college students, one group with and one without a history of CSA. The incarcerated CSA group means showed elevations on scales F, 4, 6, 7, and 9. The college CSA group means showed elevations only on scale 9. The non-abused college group means showed no elevations. Significant differences were found between the non-abused college group and the incarcerated CSA group on scales L, F, 1, 3, and 4. No significant differences were found between college CSA and college non-abused, or between college CSA and incarcerated CSA groups. The findings of these studies put in question the ability of the shortened versions of the MMPI to produce the same profiles as the full-length version of the instrument.

Research with the MMPI-2 has shown similar patterns to those seen with the original MMPI. Follette, Naugle, and Follette (1997) derived a five-cluster solution of MMPI-2 profiles among females who presented for group counseling regarding childhood sexual abuse. The first
Cluster means showed significantly high elevations on scales F, 2, 6, and 7. Cluster two means showed an even higher F scale, with other significant elevations on scales 2, 4, 5, 6, 7, 8, and 0. Cluster 3 means showed a scale 4 spike with no other significant elevations. Cluster 4 means showed extreme elevations on scales F, 1, 2, 3, 4, 6, 7, 8, and 0. Cluster 5 means showed no significant elevations. Thus, three of the clusters showed a high F, and two showed floating profiles.

Knisely, Barker, Ingersoll, and Dawson (2000) looked at a group of pregnant and recently postpartum outpatients who were given a DSM-IV diagnosis of substance abuse. They compared those who reported sexual abuse to those who did not and found significantly higher T scores for the abused group on scales F, 1, 2, 3, 4, 6, 7, and 8. Profiles of the abused group elicited an inverted V in the validity scales, a 4-5-6 configuration, and a floating profile. It was also determined that a cutoff T score of 63 on Keane's post traumatic stress disorder scale (PK) correctly classified 75% of the abused and 46% of the non-abused.

Lucenko, Gold, Elhai, Russo, and Swingle (2000) compared MMPI-2 profiles of female outpatients reporting CSA based on coercion strategies used by their perpetrators. They found the use of bribes contributed to higher levels of symptomatology on scales 6, 7, 8, and PK. They found no significant main effects for force or interactions between bribe and force. They concluded that the use of bribes to coerce individuals into submitting to sexual abuse was associated with higher levels of anxiety and posttraumatic symptoms.

Griffith, Myers, Cusick, and Tankersley (1997) looked at CSA as it pertained to sexual orientation. They found that women with CSA histories scored significantly higher on scales 1, 2, 4, 6, 7, 8, and 9 than non-abused. The CSA group’s mean scores also showed an 8-4 code type and a scale 4-5-6 configuration. In comparing heterosexual and lesbian females, it was found that
heterosexual females scored significantly higher on scale 2. However, it was concluded that the MMPI-2 could be used to detect a history of childhood sexual abuse in both heterosexual and lesbian females.

Elhai, Frueh, Gold, Gold, and Hamner (2000) compared Vietnam veterans and individuals with CSA, all of whom were outpatients diagnosed with PTSD. They found that the CSA group scored significantly higher on scales 4, 7, 8, and 9, and lower on scale 0. However, when controlling for age, most group differences disappeared. Means for the two groups showed nearly identical validity scale profiles, with scale F being highly elevated. There was a 35-point difference between the means of scale F in relation to scales L and K, yielding an inverted V pattern. Floating profiles and 4-5-6 configurations were seen in the mean profiles of both groups.

Gregg and Parks (1995) compared existing records of psychiatric patients reporting a history of childhood sexual abuse to a group reporting neither CSA nor any similar childhood trauma. They examined only scales 2, 4, 8, and Schlenger’s posttraumatic stress disorder scale (PS). It was found that patients reporting CSA scored significantly higher than non-abused patients on each of the four scales. Similarly, Elhai, Gold, Mateus and Astaphan (2001) examined only scale 8 of the MMPI-2 in female outpatients seeking treatment for after-effects of CSA. They discovered that depression and dissociation were the greatest predictors of an elevation on scale 8.

Through the use of discriminant analyses, two attempts have been made using the 567 items of the MMPI-2 to develop a scale that could identify women with a history of CSA (Griffith, Myers, & Tankersley, 1996; Korbanka, 1997). However, the individual items used to develop the scales may indicate general maladjustment or psychopathology, as psychiatric inpatients have scored equally high on one scale (Brophy, 1997). In summary, research with both
the original Minnesota Multiphasic Personality Inventory (MMPI) and the revised edition (MMPI-2) has made several attempts to discover a profile for adults with a history of childhood sexual abuse, but these efforts have failed so far to adequately distinguish CSA from other psychiatric disorders.

No research has been published using quantitative electroencephalographs (QEEGs) with adults reporting childhood sexual abuse. However, one QEEG study has been done in children and several neuroimaging studies have been done with adults through the use of electroencephalographs (EEG), positron emission tomography (PET), magnetic resonance imaging (MRI), and computerized tomography (CT) scans. Research with standard EEG has produced the most consistent differences between abused and non-abused groups, with most abnormalities showing slow or spiked waveforms in the temporal areas. Researchers have hypothesized that severe stress caused by childhood trauma alters the developing brain in several ways. Research has focused on limbic system structures and their resultant activity in the temporal lobes. There are several ways in which the developing brain may be altered by stress, including dysregulation of the hippocampus and amygdala resulting in temporal lobe abnormalities, decreased hippocampal volume, increased left hemisphere abnormalities, reduced corpus collosum size, and dysregulation of the cerebellar vermis (Teicher, 2002; Teicher, Anderson, Polcari, Anderson, & Navalta, 2002; Teicher, Anderson, Polcari, Anderson, Navalta, & Kim, 2003).

If the stress of trauma affects the limbic system through over-stimulation, it is expected that the temporal lobes will show resultant abnormalities, as the limbic system and temporal lobes are intensely linked. Teicher, Glod, Surrey, and Swett (1993) used the Limbic System Checklist-33 (LSCL-33) to measure somatic, sensory, behavioral, and memory symptoms
suggestive of temporal lobe epilepsy in 253 outpatients. A total of 56% of these individuals reported some type of abuse during their lifetime, 16% reported both physical and sexual abuse, 30% reported physical abuse only, and 10% reported sexual abuse only. It was found that LSCL-33 scores were 49% higher for those reporting only sexual abuse, and 113% higher for those reporting both physical and sexual abuse. When looking at individuals who were under the age of 18 at the time of abuse, LSCL-33 scores were 66% higher for those reporting only sexual abuse, and 147% higher for those reporting both physical and sexual abuse.

Anderson, Teicher, Polcari, and Renshaw (2002) used functional MRI (fMRI) measures of T2 relaxometry to assess blood flow in the cerebellar vermis of 24 adults, 8 of whom reported a history of CSA. The vermis has a high density of glucocorticoid receptors, and hence is hypothesized to be greatly affected by the release of stress hormones. The vermis modulates the release of norepinephrine and dopamine, so dysregulation of the vermis may result in symptoms of depression, psychosis, hyperactivity, and impaired attention. Results of this study showed that the CSA group showed higher T2 relaxation time in the vermis when compared to the control group. No significant differences were found in T2 relaxation times in the cerebral or cerebellar hemispheres. T2 relaxation times in the vermis also correlated highly to temporal lobe epilepsy symptoms as measured by the LSCL-33.

Bremner, Randall, Vermetten, Staib, Bronen, Mazure, Capelli, McCarthy, Innis, and Charney (1997) used MRI-based measures to determine hippocampal volume of patients diagnosed with PTSD due to childhood abuse. They compared 17 adults who reported severe childhood sexual and/or physical abuse to a group of non-abused clinical adults matched for gender, age, race, handedness, education, height, weight, and years of alcohol abuse. A 12% reduction in volume in the left hippocampus was found in the abused group. There was also a
strong correlation between years of sexual abuse and reduction in hippocampal volume. In addition, the abused group showed a larger left temporal lobe volume. No differences in amygdala volume were found.

Evoked potentials and PET scans recorded during the recall of traumatic events have shown differences in right and left hemisphere reactions. Schiffer, Teicher, and Papanicolaou (1995) compared auditory probe evoked potentials of 10 individuals with a history of childhood abuse to 10 individuals who denied childhood trauma. The abused group showed significant left dominant asymmetry during the neutral imagery, which shifted significantly to the right when recalling a painful childhood memory. Non-abused individuals showed no significant asymmetries and no shift between tasks. Using PET scans, Rauch and colleagues (Rauch, van der Kolk, Fisler, Alpert, Orr, Savage, Fischman, Jenike, & Pitman, 1996) showed that during symptom provoking imagery, eight individuals with PTSD showed increases in blood flow in right-sided limbic, paralimbic, and visual cortex areas. They found decreases in left inferior frontal and middle temporal cortex areas. Increases in blood flow (hyperperfusion) would be associated with faster frequency brainwave activity, whereas decreases (hypoperfusion) would be associated with slower frequency waves. Bremner, Narayan, Staib, Southwick, McGlashan, and Charney, (1999) compared CSA females with and without PTSD, and found they differed significantly in cerebral blood flow when listening to a script depicting CSA events. PET imaging showed increases in the posterior cingulate, anterolateral prefrontal cortex, and motor cortex, but only for the PTSD group. The PTSD group also showed decreases in blood flow in the anterior cingulate, right hippocampus, visual association cortex, supramarginal gyrus, and fusiform/inferior temporal gyrus. Both groups showed increases in cerebellum, temporal pole, left inferior frontal gyrus, and thalamus. Similar findings were seen in another PET study that
compared 16 adult females with a history of CSA, 8 of whom were diagnosed with PTSD, and 8 of whom did not meet PTSD criteria (Shin, McNally, Kosslyn, Thompson, Rauch, Alpert, Metzger, Lasko, Orr, & Pitman, 1999). It was found that both groups exhibited cerebral blood flow increases in the orbitofrontal cortex and anterior temporal regions during trauma imagery. However, these increases were greater in those females with a diagnosis of PTSD. The PTSD group also showed greater increases in blood flow in bilateral anterior frontal regions. The non-PTSD group showed greater increases in insular cortex and anterior cingulate gyrus regions. Only the PTSD group showed any increase in the left inferior frontal gyrus in traumatic versus neutral imagery conditions.

EEG and QEEG studies have also shown left-right differences in this population. Ito, Teicher, Glod, Harper, Magnus, and Gelbard (1993) looked at EEG abnormalities in 115 child and adolescent inpatients. They found that individuals with a history of abuse were 3.58 times more likely to show EEG abnormalities. The majority of these abnormalities occurred in frontal, temporal, and anterior regions, with abused individuals 2.7 to 3.1 more likely to show abnormalities in these areas. Left-sided abnormalities were 2.5 times greater in the abused group, and all of the left-sided abnormalities seen in the abused group were in the temporal lobes. Using the QEEG, Ito, Teicher, Glod, and Ackerman (1998) compared 15 hospitalized children who had experienced severe physical or sexual abuse to 15 non-abused children. They found higher levels of left hemisphere coherence in the abused group. Also present in this group was a significantly greater left hemisphere coherence as compared to the right. This left-right difference was greatest between sites C3 and C4, T3 and T4, and T5 and T6.

Coons, Bowman, and Milstein (1988) studied 50 patients diagnosed with dissociative identity disorder. They found that 68% of these patients reported a history of CSA, with only 4%
reporting no abuse at all during childhood. Of the 30 individuals who underwent EEGs, 7 showed abnormalities. These abnormalities included intermittent and generalized spiking, multiple spikes and paroxysm in the left parasagittal area, intermittent frontal paroxysmal slowing, temporal spike and wave paroxysms, mild non-specific abnormalities, mild diffuse slowing, and right parasagittal sharp activity and spikes. Also seen in the 30 individuals who received EEGs were 2 mildly abnormal EEGs, and 2 showing paroxysmal spike and slow wave deformities. The others either showed medication effects or were normal. Coons and Milstein (1992) also looked at 25 individuals diagnosed with psychogenic amnesia and found that 52% reported a history of CSA, with 28% reporting no childhood trauma at all. Only 3 individuals showed EEG abnormalities. These abnormalities included occasional generalized spike and wave discharges, diffuse sharp and slow wave discharges, and bilateral temporal lobe spikes.

Blake, Pincus, and Buckner (1994) looked at neurological examinations of 31 individuals accused of murder. About a third (32.3%) of these individuals reported a history of CSA. EEGs, MRIs, and/or CT scans showed frontal dysfunction in 64.5% of this sample. Temporal lobe abnormalities were found in 29%. Of the 20 individuals who had EEGs, 8 showed abnormalities. Types of abnormalities included focal temporal slowing, bi-temporal spikes and sharp waves with slowing in the parietal and temporal areas. Of the 19 individuals with MRIs or CT scans, 9 showed abnormalities consisting mostly of temporal lobe atrophy and white matter changes.

Evans and Claycomb (1999) looked at QEEGs of 10 men with histories of violent behavior and dissociative experiences. They found that 6 of the 10 had excessive relative power in the alpha frequency band (7.0 – 13.0 Hz) in frontal and sometimes temporal areas. Wave forms of 4 other subjects showed paroxysmal large amplitude delta (.5 – 3.5 Hz) waves in the frontal and temporal areas. The six individuals with predominate alpha reported more
dissociation, stating they either did not remember committing the crime or believed they were under external control. The four individuals with predominate delta had difficulty identifying motivation or rational causes for their behaviors.

It was also in this report by Evans and Claycomb (1999) that a possible connection between CSA and high alpha was hypothesized. It was noted that individuals with high alpha patterns tend to be easily hypnotized. Because dissociation has been described as a form of self-hypnosis, a high alpha pattern may serve as a dissociative coping technique for individuals who have experienced a trauma. Putnam, Helmers, Horowitz, and Trickett (1995) found no significant difference in hypnotizability of 54 girls who had been sexually abused when compared to 51 matched controls, but they did find that highly hypnotizable individuals were significantly more dissociative as measured by the Child Dissociative Checklist. They found that individuals who were both highly dissociative and highly hypnotizable had experienced an earlier onset of abuse, and typically had multiple perpetrators.

In a pilot study exploring QEEG patterns associated with CSA (Townsend & Black, 2001) it was found that an adult outpatient CSA group actually showed significantly lower alpha relative power in all but 2 of the 19 sites in the International 10/20 electrode placement system when compared to a non-abused outpatient group. This contradicted previous hypotheses, and instigated further questioning of what other differences might exist in brain wave patterns. Further analyses are being performed concerning possible differences in alpha distribution and coefficient of variation in posterior sites (Black, Townsend, Bodenhamer-Davis, 2001).

The pilot study by Townsend and Black (2001) also developed two prediction models for CSA group membership using the MMPI-2 and alpha relative power. Potential predictors for the models were chosen using a principal components analysis to reduce the number of variables.
The variables selected from this procedure were included in two- and three-predictor logistic regression models. Bootstrapping techniques were used to validate and calibrate the models due to the small sample size. Two models were chosen based on statistical and clinical significance. The first model included two predictors, scale 4 of the MMPI-2 and alpha relative power at T6. Dysfunction in the temporal lobes is often related to problems in interpretation of one’s environment, which can lead to abnormal thinking patterns and social misperceptions. Because these symptoms relate closely to the Psychopathic Deviate scale 4, this model was called a model of social maladjustment. After validation and calibration, this model accounted for 55.8% of the variance between the two groups ($R^2 = .596$, $p = .0008$; corrected $R^2 = 0.558$). The second predictor model included three predictors, and was labeled a depression model. The three predictors in this model were scale 2 Depression, and alpha relative power at sites F3 and FP1. This model accounted for 60.7% of the variation between the two groups ($R^2 = 0.720$, $p = .0003$; corrected $R^2 = .607$). This model seemed clinically meaningful, as prior research has shown depression is associated with asymmetries in alpha between left and right frontal sites (Baehr, Rosenfeld, Baehr, & Earnest, 1999; Henriques & Davidson, 1992).

The purpose of the current study was to further explore differences in the MMPI-2 and QEEG of adults with a history of CSA as compared to adults without a history of childhood abuse. This study expanded on the pilot study in three main ways. First, a larger sample size was incorporated in order to increase statistical power. Second, activity in other frequency bandwidths was examined through the use of bandwidth ratios. Lastly, models to predict membership in the CSA group were developed using MMPI-2, alpha relative power, and bandwidth ratios. This study had three main objectives:
1) Exploration of differences between CSA and non-abused groups in MMPI-2 basic scales, and supplementary scales PK and PS.

2) Determination of classification rates for the three MMPI-2 patterns of inverted V in the validity scales, floating profile, and 4-5-6 configuration. Classification rates were determined for the three patterns together, and for each pattern individually.

3) Development of models for prediction of membership in the CSA group. Predictors for the models included MMPI-2 scales and alpha relative power. Bandwidth ratios were analyzed apart from other data in attempt to develop a separate model.
METHOD

Participants. A total of 46 individuals were included in this study. Participants included the 24 original pilot study subjects, plus 22 newly recruited participants. Study data for the original 24 participants consisted of archived files of past clients of the University of North Texas Department of Rehabilitation, Social Work and Rehabilitation Neurotherapy Lab. All 24 subjects had been given a Minnesota Multiphasic Personality Inventory - 2™ (MMPI-2) and quantitative electroencephalogram (QEEG) at intake. Twelve of these clients had reported a history of childhood sexual abuse (CSA). A control group was gathered using former clients who denied a history of any type of childhood abuse and were matched to the experimental group for handedness, age, and gender. Newly recruited participants included 11 individuals who reported a history of childhood sexual abuse matched for handedness, age, and gender to 11 newly recruited participants who denied any type of abuse as a child. These new participants were recruited primarily from fliers distributed on a university campus and in other health care clinics in the area. Therefore, many of the new participants were college students. Inclusion criteria for the CSA group included being 18 years or older, currently self-reporting childhood sexual abuse that occurred before the age of 14, and having MMPI-2 and QEEG assessment that occurred prior to receiving any electroencephalographic (EEG) biofeedback treatment. Inclusion criteria for the non-abused group also included being 18 years or older and having a MMPI-2 and QEEG assessment before receiving any EEG biofeedback treatment. Individuals reporting any type of abuse as a child were excluded from the non-abused group in order to reduce possible confounding effects. Participants under the age of 18 were not included, as the MMPI-2 is valid only for individuals 18 years of age or older. Participants were not excluded based on gender or race. Additional exclusion criteria for newly recruited participants in both groups included being
free from alcohol, caffeine, nicotine, prescription or over-the-counter medication, or any other
substance that would effect the EEG. Individuals using any of these substances were asked to
refrain from use for a sufficient amount of time to allow for washout before the EEG was
collected. Times required for washout of substances were determined by multiplying the half-life
of the substance by seven.

Measures. All participants were given the MMPI-2 and a QEEG. The MMPI-2 is a 567-
item objective personality inventory. It yields three validity scales and ten basic scales. Two
supplementary scales measuring pathology related to posttraumatic stress (by Keane and
Schlenger) are also available and were used in this study. The MMPI-2 is one of the most
utilized and researched assessment tools in use today. However, it also has many weaknesses,
including scale intercorrelations as high as .80 and excessive item overlap. The standardization
sample is overrepresentative of adults who have a post-college education and are of upper socio-
economic status, and is unrepresentative of adults with a high school education or less (Holden,
2000).

EEG data was collected using a Lexicor digital EEG system. Recordings were taken from
19 channels of the International 10/20 electrode placement system, using linked ears as the
reference. A bipolar electro-oculogram channel was used to measure eye artifacts. Recordings
were visually edited to exclude artifacts prior to analysis. NeuroRep (Hudspeth, 1999) software
was used to analyze the EEG. This program provides measures of magnitude, weighted averages,
neuro-electric images, amplitude, and relative power. The individual’s EEG indices also may be
compared with the Adult QEEG Reference Database (Hudspeth, 1999) to obtain measures of
coherence, phase, and bandwidth ratios. The QEEG information provides inferences concerning
indicators for brain dysfunction. Among the QEEG’s weaknesses is not only the possibility of
including artifact seen in the standard EEG, but also for new artifacts to arise due to data processing algorithms (Nuwer, 1997). Artifact detection and exclusion is crucial to prevent invalid QEEG reports. Additional weaknesses include inability to assess state of alertness and effects of medication (Nuwer). Also, during the analysis of the QEEG several statistical tests are performed, which increases the likelihood for significant abnormalities to occur by chance.

**Data Analyses.** To determine if significant differences existed between profiles of the CSA and non-abused groups, t-tests were performed on the three validity scales, ten basic scales, and supplementary scales of PK and PS. To control the family wise error rate due to multiple comparisons, a false discovery rate control was used. Benjamini and Hochberg (1995) have suggested this sequential Bonferroni-type procedure to control for the expected proportion of falsely rejected hypotheses.

In order to investigate differences between the CSA and non-abused groups, visual analysis was used to detect the three patterns of an inverted-V in the validity scales, floating profiles, and 4-5-6 configurations. The inverted V in the validity scales was defined as scales L and K being at least 10 T scores lower than scale F. This definition is based on validity scale interpretations set forth by Greene (1991). A floating profile is present when six or more basic scales are above a T score of 65. The 4-5-6 configuration was defined as scales 4 and 6 being at least 30 T scores above scale 5.

Because the QEEG provides a large number of variables, it was necessary to reduce the data and select only relevant predictors to be included in analyses. In order to select potential predictors to be included in a model identifying membership in the CSA group, a principal components analysis (Harrell, 2001) was performed on MMPI-2 scales and relative power at each of the 19 sites. Principal components analysis is a data reduction method used to reduce the
large number of variables to more realistic number. The recommended number of predictor
variables is one per every 10 to 20 subjects (Harrell, Lee, & Mark, 1996), thereby allowing up toﬁour predictors in this study with 46 subjects. Predictors were selected according to their
component loadings. The selected predictors were inserted into models and logistic regression
was performed with CSA as the dependent variable. A bootstrapping technique of validation and
calibration (Harrell, 2001) was used to account for the large number of variables. Bootstrapping
creates new samples through random selection with replacement of cases from the actual sample.
It provides internal validation, and allows for an unbiased estimate of model accuracy (Harrell,
Lee, & Mark, 1996). Models were chosen based on statistical and clinical significance.

As another part of the exploratory phase of this study, bandwidth ratios of alpha/delta,
alpha/theta, and alpha/beta were used to develop additional predictor models. Due to the large
number of variables, a principal components analysis was performed to reduce the number of
variables used as potential predictors. Models were developed based on statistical significance
and clinical relevance. A bootstrapping technique was used for model validation and calibration.
RESULTS

T score means and standard deviations were computed for the two group’s Minnesota Multiphasic Personality Inventory™ (MMPI-2) basic scales, and for supplementary scales PS and PK (see Table 1). The means graphed in Figure 1 illustrate the average profiles for the two groups. As shown in Table 2, when comparing MMPI-2 profiles of childhood sexual abuse (CSA) versus non-abused groups, t-tests showed significant differences in scales F ($t = -3.285, p = 0.002$), 1 ($t = -3.334, p = 0.002$), 2 ($t = -3.102, p = 0.003$), 3 ($t = -3.209, p = 0.002$), 4 ($t = -2.749, p = 0.009$), 6 ($t = -2.083, p = 0.043$), 7 ($t = -4.484, p < 0.001$), 8 ($t = -4.010, p < 0.001$), PK ($t = -3.363, p = 0.002$), and PS ($t = -3.231, p = 0.002$). When corrections were made for multiple comparisons, similar results were found, with only scale 6 no longer significant. Adjusted values were still significant for the scales of F (adjusted $p = 0.014$), 1 (adjusted $p = 0.014$), 2 (adjusted $p = 0.018$), 3 (adjusted $p = 0.014$), 4 (adjusted $p = 0.049$), 7 (adjusted $p = 0.009$), 8 (adjusted $p = 0.009$), PK (adjusted $p = 0.014$), and PS (adjusted $p = 0.014$).

Classification rates were determined for the ability of three patterns (inverted V, floating profile, and 4-5-6 configuration) to correctly identify individuals as either abused or non-abused. Each pattern was looked at individually, and then in conjunction with the other patterns. Individual MMPI-2 profiles were classified as either CSA or non-abused according to the existence of each of the three patterns. Results are shown in Table 3. Inverted V patterns in the validity scales were present in 12 of the profiles, 8 of which were from the CSA group. This pattern correctly identified 27 of the 46 participants, for an overall correct classification rate of 58.7%. Next, each MMPI-2 was classified as either CSA or non-abused according to the presence of a floating profile. This pattern was seen in 8 of the profiles, all of which were in the CSA group. It correctly identified 31 of the 46 participants, for an overall correct classification
rate of 67.4%. Next, each MMPI-2 was classified as CSA or non-abused according to the existence of a 4-5-6 configuration. This pattern was only seen in one profile, and that profile was of a non-abused participant. Therefore, it correctly classified all but one of the non-abused group, and none of the CSA group, for an overall correct classification rate of 47.8%. Finally, each MMPI-2 was classified as either CSA or non-abused according to the presence of all three patterns. Only if all three of the patterns were present was the individual classified as CSA, and none of the profiles contained all three. Thus, none of the CSA group were correctly classified, and all of the non-abused group were, for an overall correct classification rate of 50%.

With the new data, principal components analyses did not clearly identify potential predictors from the MMPI-2 scales and sites with alpha relative power. Alpha relative power at each of the 19 sites loaded onto the first component, which accounted for 53.98% of the variance, and all loadings were low (< 0.226). All of the MMPI-2 scales except L and 5 loaded onto the second component. No loadings were above 0.341, and scale K loaded negatively. Therefore, the original models from the pilot study were used to develop clinically relevant models with the new data. The pilot study model of social maladjustment, which included scale 4 from the MMPI-2 and alpha relative power at T6, accounted for over 55% (R^2 = 0.596, p = 0.0008; corrected R^2 = 0.558) of the variance in the pilot study, but only about 33% (R^2 = 0.395, p = 0.001; corrected R^2 = 0.330) in this study. This model was still significant, even though it did not predict as well with the new sample. The pilot study model of depression, which included scale 2 of the MMPI-2 and alpha relative power at sites Fp1 and F3, accounted for about 60% of the variance in the pilot (R^2 = 0.720, p = 0.0003; corrected R^2 = 0.607), but only about 29% in this study (R^2 = 0.402, p = 0.0046; corrected R^2 = 0.287). Again, the model was still significant. Two new models were found that retained the concepts of the pilot models, and were statistically
significant and clinically meaningful. The first was similar to the social maladjustment model, and included MMPI-2 scale 8 and alpha relative power at sites T5 and T6. This model accounted for almost 37% of the variance ($R^2 = 0.491, p = 0.0008$; corrected $R^2 = 0.368$). Another model was found similar to the pilot study model of depression. It included scales 2 and F from the MMPI-2 and alpha relative power at sites F7 and F3. This model accounted for about 45% of the variance ($R^2 = 0.591, p = 0.0002$; corrected $R^2 = 0.449$). A summary of the models is shown in Table 4.

Similar to the principal components analysis with alpha relative power and MMPI-2 scales, ratios at all sites loaded on the first component. This first component accounted for 68.04% of the variance, and loadings were very small ($< 0.148$). The second component accounted for 15.25% of the variance, and loadings on this component were also small ($< 0.180$). Variables loading on the second component included alpha/beta and alpha/theta ratios at all sites. However, alpha/theta ratios loaded negatively, and were greater at posterior sites. The alpha/delta ratio at site P3 showed to be a potential predictor for the model, but was unable to account for more than 25% of the variance when in models with ratios at other sites. So again, previously developed models were used as a guide to develop clinically relevant predictor models with this new ratio data. It was found that alpha/delta at P3 fit well with MMPI-2 scales used in the previous models of social maladjustment. Alpha/delta at P3, when combined in a model with scale 8 (Schizophrenia) of the MMPI-2, accounted for about 45% of the variance ($R^2 = 0.512, p < 0.0001$; corrected $R^2 = 0.448$). When alpha/delta at P3 was combined with both scale 8 and scale 4 (Psychopathic Deviate), the model accounted for about 47% of the variance ($R^2 = 0.579, p < 0.0001$; corrected $R^2 = 0.473$). Table 4 summarizes the statistics for these two models.
DISCUSSION

Similar to previous research findings, Minnesota Multiphasic Personality Inventory™ (MMPI-2) profiles of the childhood sexual abuse (CSA) group showed significant elevations when compared to the non-abused group, including scales F, 1, 2, 3, 4, 7, 8, PK, and PS. Patterns of an inverted V in the validity scales, a floating profile, and a 4-5-6 configuration were present in the CSA group, but these patterns were unable to accurately classify individuals as abused or non-abused. The best predictor among these three patterns was the floating profile, which was only present in profiles of participants in the CSA group, and correctly classified 67.4% of participants. Therefore, significant differences were seen in the MMPI-2, but this measure was unable to accurately identify adults who have experienced CSA.

Principal components analyses did not distinguish important sites with alpha relative power or ratios well, as most all sites loaded on the first component with small loadings. This likely attests to the similarities across the brain in individuals. When faced with numerous variables, reduction of the data can be problematic. As seen in this study, the use of post-hoc measures is not ideal. However, this may be the best option when exploration of the data involves numerous variables. This line of research would benefit from studies using a priori methods to reduce the number of variables. As research with adults who have experienced childhood trauma expands, this task will become more feasible, especially given the demonstrated importance of frontal and temporal sites.

Original predictor models from the pilot study were still significant, but did not account for as much variance. Models of social maladjustment and depression appear to be important determinants for identifying adults with childhood sexual abuse. The new models were still based on social maladjustment and depression, and predictor variables used in the new models
were similar to those in the pilot models. For example, new sites used in the new social maladjustment models were still temporal lobe sites. Similarly, with the new depression model, new sites were still in the left frontal region. MMPI-2 scales included in the new models were also comparable to those used in the pilot. Scales F and 2 are often seen elevated together, and many items are overlapped between scales 4 and 8 (Greene, 1991).

Although findings were similar, variations in results between this study and the pilot could be explained by differences between participants obtained from archived clinical files versus newly recruited participants. One difference between these participants is the high level of functioning seen in those who were newly recruited. They were not clinical patients, and were of above average intelligence (Black, 2003). Also, unlike pilot study subjects, the new participants were free of medication and any substances that would affect the electroencephalogram (EEG). Medication effects could account for some differences in results seen between this study and the pilot. Although these differences may have compromised the internal validity of this research, it likely strengthened the external validity. This sample is more likely to be representative of the general population, with some in treatment and some on medication, but with others who are high functioning and free of medication.

As with any reliance on self-report measures, there is also the possibility of false reports. It should be stressed that the individuals included in the study merely reported CSA or denied it, and no verification of their statement was pursued. Neither did this study look at the level of trauma reported. Many previous studies have used only severely traumatized individuals, and some have rated the severity levels of the trauma experienced by participants. Using both clinical and non-clinical participants produced similar results to the pilot, however. This seems to suggest that even those individuals who experienced mild trauma or who are high functioning...
could still be demonstrating abnormalities in brain function. Black (2003) continues to investigate this possibility.

Age at which the trauma occurred was not taken into consideration in this study either. As stated earlier in this paper, it is believed that the abundant release of stress hormones during trauma damages developing brain structures. Therefore, it stands to reason that the brain structures affected might vary according to developmental stage or age of the child when the trauma occurred. This could be tested by future research attempts to correlate patterns seen in the adult brain with trauma which occurred at different neuro-developmental stages.

This research has only touched on a few of the several measures available through the quantitative electroencephalogram (QEEG). Future studies should focus on frequencies in the delta and theta range, as some differences in ratios in these frequency bands were seen between the two groups in this study. Research is already being conducted to analyze coherence differences and EEG abnormalities such as asymmetry, epileptiform activity, low voltage fast patterns, focal slowing, and alpha attenuation when eyes open (Black, 2003).

The results of this study suggest that the impact of trauma during childhood may have greater implications than previously believed. Similar to previous neuroimaging studies, these results provide evidence for temporal and frontal lobe abnormalities, especially in the left hemisphere. The areas affected suggest possible long-term problems with depression and social difficulties. These results suggest that the effects of childhood trauma extend into adulthood and are not only psychological in nature, but also physiological. It also appears that these physiological differences exist even in adults who are high functioning and who may not be presenting with psychological concerns. Adults presenting with psychological concerns can likely benefit from psychotherapy. In addition, EEG biofeedback may prove helpful in
addressing the physiological abnormalities seen in the cortical functioning of these individuals. The development of neurotherapy protocols for individuals with a history of CSA will be most beneficial. It is hoped that by determining abnormalities and differences in the QEEG, neurotherapy protocols addressing EEG abnormalities may be developed to enhance treatment of adults who have experienced childhood trauma.
Figure 1

*Graphed means of MMPI-2 T scores for the two groups*
Table 1

*Group means and standard deviations of MMPI-2 scores*

<table>
<thead>
<tr>
<th>Scale</th>
<th>CSA M</th>
<th>CSA SD</th>
<th>Non-abused M</th>
<th>Non-abused SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>51.78</td>
<td>8.135</td>
<td>47.35</td>
<td>7.572</td>
</tr>
<tr>
<td>F</td>
<td>65.13</td>
<td>23.281</td>
<td>48.35</td>
<td>7.625</td>
</tr>
<tr>
<td>K</td>
<td>50.17</td>
<td>12.134</td>
<td>52.70</td>
<td>9.795</td>
</tr>
<tr>
<td>1</td>
<td>66.52</td>
<td>16.470</td>
<td>52.22</td>
<td>12.329</td>
</tr>
<tr>
<td>2</td>
<td>65.91</td>
<td>14.077</td>
<td>53.30</td>
<td>13.458</td>
</tr>
<tr>
<td>3</td>
<td>64.91</td>
<td>16.629</td>
<td>51.48</td>
<td>11.253</td>
</tr>
<tr>
<td>4</td>
<td>63.87</td>
<td>11.303</td>
<td>55.48</td>
<td>9.302</td>
</tr>
<tr>
<td>5</td>
<td>52.35</td>
<td>9.852</td>
<td>54.13</td>
<td>10.195</td>
</tr>
<tr>
<td>6</td>
<td>59.91</td>
<td>14.058</td>
<td>51.61</td>
<td>12.964</td>
</tr>
<tr>
<td>7</td>
<td>66.78</td>
<td>11.751</td>
<td>50.74</td>
<td>12.505</td>
</tr>
<tr>
<td>8</td>
<td>68.78</td>
<td>16.220</td>
<td>53.22</td>
<td>9.135</td>
</tr>
<tr>
<td>9</td>
<td>52.61</td>
<td>12.010</td>
<td>50.78</td>
<td>8.213</td>
</tr>
<tr>
<td>0</td>
<td>54.87</td>
<td>11.218</td>
<td>50.43</td>
<td>11.504</td>
</tr>
<tr>
<td>PK</td>
<td>62.70</td>
<td>16.272</td>
<td>49.70</td>
<td>8.885</td>
</tr>
<tr>
<td>PS</td>
<td>62.74</td>
<td>16.829</td>
<td>49.91</td>
<td>8.908</td>
</tr>
</tbody>
</table>
Table 2

T-test Results Comparing MMPI-2 Scales of CSA versus Non-abused Groups

<table>
<thead>
<tr>
<th>Scale</th>
<th>t</th>
<th>p</th>
<th>adjusted p</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>-1.914</td>
<td>0.062</td>
<td>0.281</td>
</tr>
<tr>
<td>F</td>
<td>-3.285</td>
<td>0.002**</td>
<td>0.014*</td>
</tr>
<tr>
<td>K</td>
<td>0.776</td>
<td>0.442</td>
<td>1.000</td>
</tr>
<tr>
<td>1</td>
<td>-3.334</td>
<td>0.002**</td>
<td>0.014*</td>
</tr>
<tr>
<td>2</td>
<td>-3.102</td>
<td>0.003**</td>
<td>0.018*</td>
</tr>
<tr>
<td>3</td>
<td>-3.209</td>
<td>0.002**</td>
<td>0.014*</td>
</tr>
<tr>
<td>4</td>
<td>-2.749</td>
<td>0.009**</td>
<td>0.049*</td>
</tr>
<tr>
<td>5</td>
<td>0.603</td>
<td>0.550</td>
<td>1.000</td>
</tr>
<tr>
<td>6</td>
<td>-2.083</td>
<td>0.043*</td>
<td>0.214</td>
</tr>
<tr>
<td>7</td>
<td>-4.484</td>
<td>&lt;0.001***</td>
<td>0.009**</td>
</tr>
<tr>
<td>8</td>
<td>-4.010</td>
<td>&lt;0.001***</td>
<td>0.009**</td>
</tr>
<tr>
<td>9</td>
<td>-0.602</td>
<td>0.550</td>
<td>1.000</td>
</tr>
<tr>
<td>0</td>
<td>-1.324</td>
<td>0.192</td>
<td>0.796</td>
</tr>
<tr>
<td>PK</td>
<td>-3.363</td>
<td>0.002**</td>
<td>0.014*</td>
</tr>
<tr>
<td>PS</td>
<td>-3.231</td>
<td>0.002**</td>
<td>0.014*</td>
</tr>
</tbody>
</table>

* p < .05    ** p < .01    ***p < .001
Table 3

*Number of Correct and Incorrect Classifications and Total Classification Rates for Each of the Three MMPI-2 Patterns*

<table>
<thead>
<tr>
<th>Pattern</th>
<th>CSA Correct</th>
<th>Incorrect</th>
<th>Non-abused Correct</th>
<th>Incorrect</th>
<th>Total % Correct</th>
<th>Incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inverted V</td>
<td>8</td>
<td>15</td>
<td>19</td>
<td>4</td>
<td>58.7</td>
<td>41.3</td>
</tr>
<tr>
<td>Floating</td>
<td>8</td>
<td>15</td>
<td>23</td>
<td>0</td>
<td>67.4</td>
<td>32.6</td>
</tr>
<tr>
<td>4-5-6</td>
<td>0</td>
<td>23</td>
<td>22</td>
<td>1</td>
<td>47.8</td>
<td>52.2</td>
</tr>
<tr>
<td>All 3 patterns</td>
<td>0</td>
<td>23</td>
<td>23</td>
<td>0</td>
<td>50.0</td>
<td>50.0</td>
</tr>
</tbody>
</table>

*Note.* Inverted V refers to the validity scales of L and K being at least 10 T scores lower than scale F. Floating refers to a floating profile in which 6 or more basic scales are above a T score of 65. 4-5-6 refers to the configuration in which scales 4 and 6 are at least 30 T scores above scale 5.
Table 4

*R², Corrected R², and Significance Levels of Predictor Models Developed Using MMPI-2 Scales, Alpha Relative Power, and Alpha/Delta Ratio at Sites in the International 10-20 Placement System*

<table>
<thead>
<tr>
<th>Model</th>
<th>R²</th>
<th>p</th>
<th>corrected R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale 4 + T6</td>
<td>0.395</td>
<td>0.001</td>
<td>0.330</td>
</tr>
<tr>
<td>Scale 2 + Fp1 + F3</td>
<td>0.402</td>
<td>0.0046</td>
<td>0.287</td>
</tr>
<tr>
<td>Scale 8 + T5 + T6</td>
<td>0.491</td>
<td>0.0008</td>
<td>0.368</td>
</tr>
<tr>
<td>Scale 2 + Scale F + F3 + F7</td>
<td>0.591</td>
<td>0.0002</td>
<td>0.449</td>
</tr>
<tr>
<td>Scale 8 + alpha/delta P3</td>
<td>0.512</td>
<td>&lt;0.0001</td>
<td>0.448</td>
</tr>
<tr>
<td>Scale 8 + Scale 4 + alpha/delta P3</td>
<td>0.579</td>
<td>&lt;0.0001</td>
<td>0.473</td>
</tr>
</tbody>
</table>
REFERENCES


