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TEST - RETEST RELIABILITY OF EEG DURING BASELINE, READING AND DRAWING CONDITIONS IN 10 TO 12 YEAR OLD BOYS

by

Kenneth M. Graap

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled: TEST - RETEST RELIABILITY OF EEG DURING BASELINE, READING AND DRAWING CONDITIONS IN 10 TO 12 YEAR OLD BOYS, submitted by KENNETH M. GRAAP in partial fulfilment of the requirements for the degree of MASTER OF EDUCATION in EDUCATIONAL PSYCHOLOGY. GF.

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Abstract

A test-retest reliability study of quantitative EEG (QEEG) was carried out while seventeen normal fifth and sixth grade boys were engaged in baseline (eyes open & eyes closed) and active (reading & drawing) tasks. Results are reported in terms of Spearman rank order correlations for each of seven individual sites (FZ, CZ, PZ, C3, C4, P3, P4, placed according to the international 10-20 system), and for each of the four tasks. Findings suggest that the recording of on task EEG is stable across the 8 day retest interval. On task EEG appears to be slightly less reliable than the eyes open or eyes closed baseline conditions. Possible reasons for the reduced reliability are discussed with focus on the parallel nature of the tasks and degree of difficulty. Results indicate reliability coefficients which vary from a low of .35 to a high of .96. Reliabilities seem to vary with channel, band, and task.

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Rationale for Study

> "My experience is what I agree to attend to. Only those items which I notice shape my mind." (James, 1890, p.403 as cited in Bakan (Ed) 1966, p.4).

One's ability to attend is a prerequisite for perception, discrimination and learning. One will not learn what has not been attended to. The psychological and psychosocial implications for individuals who have difficulty attending can be profound.

The concept of attention has long been of interest to researchers. Attention Deficit Hyperactivity Disorders (ADHD), specifically, have been subject to considerable study. Recently, researchers have focused on the possible uses of electroencephalography (EEG) in the diagnosis and treatment of ADHD. EEG differences between those individuals with ADHD and those considered normal have been demonstrated by Janzen (1992) and Mann, (1990).

Mann (1990) theorized that neurologic differences, as demonstrated by EEG differences, between normal and ADHD children would be magnified by "stressing" the brain with an on task activity. (On task refers to a wide variety of higher cognitive functions such as those required for reading and drawing.) This process is thought to be analogous to a stress test in cardiac diagnostic work. Mann tested this theory and demonstrated that EEG differences between normal and attention disordered children increased on task. However, the reliability and ultimately the validity of the EEG measures while subjects perform cognitive tasks, such as, reading and drawing, has not been established. If one is to utilise EEG as a basis establishing differences between groups, it would seem prudent to establish the relative stability of the measures in one or both groups.

The availability of relatively inexpensive computers has allowed many researchers to take up the search for EEG differences between groups of people. As this area of research progresses it is necessary to establish the reliability and validity of the EEG measures used to establish group differences. While many studies have been done to assess the reliability of eyes open resting or eyes closed resting EEG measures, to date, examination of the reliability of "on task" EEG measures has been overlooked.

It is important to distinguish between measures of reading fluency or drawing proficiency in the EEG and measures designed to assess the relative amount of cortical engagement on task. Broad band EEG parameters have been purported to reflect attention and arousal brought about by cognitive tasks. They do not measure task proficiency, for example, how well one reads or draws. By determining that the tasks result in the same relative positions of subjects, when rank ordered according to the amplitude of broad band EEG activity recorded on two separate occasions, an estimate of the reliability of on task EEG can be documented. The purpose of this study is to establish test-retest reliability coefficients for broad band EEG parameters for boys aged 9 to 13 years, who are engaged in reading and drawing tasks.

Chapter 2

Literature Review

History of Electroencephalography (EEG)

EEG first entered the research arena around 1875 as a way to look at electrical activity in the brains of animals. Richard Canton, an English physician, was the first to identify what he termed "feeble currents of varying direction..." (in Niedermeyer, 1993a, p. 2) in animals. Hans Berger, a German neuropsychiatrist, is generally regarded as the person who first documented the human EEG. In 1929 the first of his fourteen papers, which were all titled On the Electroencephalogram of Man, was published (cited in Niedermeyer, 1993a).

EEG has evolved since the work of Berger. Technical advances over the past 65 years have resulted in increased accuracy in the measurement of the EEG signal, specifically in the frequency and amplitude domains. There have also been many standards established which pertain to the placement of electrodes (Jasper, 1958), the recording procedures and the interpretation of EEG records.

Despite all of the advances in EEG, research has not left Berger's work so far behind. As Gloor (1969) noted:

> Although many of the specific concepts Berger elaborated in his papers are now dated, his thoughts on the physiologic interpretation of the human electroencephalogram and on its relationship to the integrated function of the brain as a whole are still fascinating today. We have to admit that many of the questions that he asked himself, with the greatest insistence, still remain unanswered and represent a challenge for future investigators in this field (p.649).

Physiologic Basis of EEG

EEG signals recorded from the scalp are subject to the influence of many different variables and electrical principles. Perhaps, as a result of the confounded nature of the measure, there is no one model to explain the generation of the electrical potentials recorded on the EEG. One theory is that EEG is comprised of a summation of post synaptic potentials generated at the cellular level (Speckman & Elger, 1993). This theory implies that an event must occur which causes a change in polarization of the cellular membrane. This change in cellular polarity ultimately results in the generation of a field potential, which when combined with enough other similar potentials, may be observed at the scalp with sensitive electrodes and recording equipment. In summary, EEG is always the result of, or an effect of another event.

Uses of EEG

Despite the controversy and ambiguity surrounding the source of EEG activity, research involving EEG has been extensive. Traditionally, EEG has been used to detect neurologic abnormalities associated with epilepsy, brain lesions or tumors (Fischer-Williams, 1993), sleep disorders (Niedermeyer, 1993b), and cerebral death (Harvard Committee on Brain Death, 1968). More recently EEG has been used to explore a diverse range of disorders such as learning disabilities (John, et al., 1983), dyslexia (Duffy, Denckla, Bartels & Santini, 1979; Hanley and Sklar, 1976), attention deficit disorders (Janzen, 1992; Lubar, 1991; Mann, Lubar, Zimmerman, Miller & Muenchen, 1992), and alcoholism (Cohen, Porjesz & Begleiter, 1993). Additionally, it has been used to explore areas of the brain used in a variety of cognitive tasks such as, mathematics (Inouye, Shinosaki, Iyama & Matsumoto 1993), reading (Janzen 1992; Mann, 1990) and drawing (Janzen 1992; Mann, 1990). (For a more complete discussion of early work in task related EEG the reader is referred to Gevins & Schaffer, 1980.)

EEG has also been utilized to distinguish different stages of sleep. In the 1950's, rapid eye movement (REM) sleep was first documented by Aserinsky and Kleitman (1953). Eventually, all five stages of sleep could be defined by EEG events, for example, stage two sleep is characterized by the presence of sleep spindles, vertex waves and K-complex waves (Niedermeyer, 1993b, p. 155). Sleep stages three and four are defined in part by the relative amount of delta or slow wave activity present in the EEG record (Broughton, 1993).

In this paper, the terms Traditional and Quantitative EEG (QEEG) will be utilized to describe different approaches to the recording and analysis of EEG information. Though currently the distinction between Traditional EEG and QEEG is somewhat blurred (because of advances in technology), fundamental differences between Traditional EEG and QEEG still do exist.

Traditional EEG

Traditionally, EEG studies employ analog EEG recording devices equipped with ink pens and recording paper. The paper records are then scored by experts. Four functional states are generally used to assess the normality of the recording. Two of the states are, eyes open and eyes closed. These may be seen as passive states. The remaining two states are photic stimulation and hyperventilation. These are referred to as active states. Active in this context refers to the facilitation of abnormal or epileptiform waves in the EEG record (Takahashi, 1993).

Each of the passive and active states produces an identifiable change in the EEG pattern, which is thought to be associated with a "normal" response. Deviations away from this normal response may be identified as abnormal. Descriptions such as diffuse slowing or paroxysmal activity are examples of abnormal responses. Abnormal wave patterns are generally recognized as being associated with specific seizure disorders, tumors or lesions. However, it is possible for a subject to have an abnormal EEG record and have no behavioral signs or symptoms.

If the four states (eyes open, eyes closed, hyperventilation and photic stimulation) do not elicit abnormal recordings, sleep or sleep deprived EEGs may be used in attempts to illicit seizure activity in the EEG record.

Quantitative EEG

Quantitative EEG uses computerized digital technology to display EEG records on computer screens. The records are then decimated by computer algorithms and reported as numeric values.

The roots of QEEG can be traced to Berger and Dietsch, who first attempted to quantify the human EEG in 1932 (Niedermeyer, 1993). They painstakingly applied Fourier's analysis (based upon the work of J.B.J. Fourier 1768-1830), by hand, to short sections of the EEG record.

Not until the technical revolution of the 1950's was electronic technology widely applied to the analysis of EEG records. Walter and Shipton (1951) produced a cathode ray tube (CRT) array which measured the amplitude of the EEG coming from a subjects scalp. The CRT tubes got brighter as the amplitude of the signal at the corresponding scalp location got larger.

During the 1960's the computer revolution made digital computer available to a wide range of researchers. Computer analysis provided a precise and objective measurement of the EEG record (Gevins & Schaffer, 1980).

There are a variety of analytical methods associated with computer analysis of the EEG. For example, various computer implementations of Fourier's algorithm have used. Fourier's analysis involves fitting a series of sine waves to the complex patterns associated with the human EEG. In this way, complex analog EEG waves are converted to a series of numeric values associated with different frequency components present in the original EEG record. One of the better known alternatives to a Fourier analysis is the zero crossing analysis (Cohen, 1976). Whichever analysis is chosen, the EEG signal can be accurately and repeatedly quantified through the use of a computer algorithm.

Combining Traditional and QEEG

Most of the research since the 1960's has been done with the QEEG. It was initially thought that the QEEG would all but replace the Traditional EEG in a short time. This has not occurred but, the two areas are being combined, as seen in sleep and epilepsy work, to a greater extent than ever before.

Traditional EEG is frequently recorded in parallel with QEEG. The basic assessment may still take place with the paper tracing, but the digital record can be subjected to many additional analyses, including mathematically changing the reference and the displayed montage. Both changing the reference and rearranging the montage may be useful in localizing the source of an abnormality. Additionally, once digital data is available, statistical tests can be applied. Data can be re-averaged and re-artifacted, in a virtually unlimited number of ways, to test different hypotheses.

With the advent of computer analysis many began to speculate that the EEG record contained information other than the reflection of a specific neuro-anatomical abnormality. Many studies undertaken with QEEG can be seen as searches for EEG correlates of an external behavior such as, lack of ability to read (Duffy, Denckla, Bartels & Sandini, 1980). These studies either attempted to define the normal range of EEG activity for a variety of complex cognitive and developmental tasks, or attempted to demonstrate EEG differences between behaviorally different groups of people.

EEG abnormalities alone are not sufficient to be diagnostic of certain behaviorally defined disorders, as in Traditional neurologic EEG recordings. Often group differences are used to suggest underlying neurologic differences between groups demonstrating behavioral disorders. These underlying differences often would not fit the traditional definition of EEG abnormality.

The combination of Traditional EEG and QEEG can be seen as advantageous to the newer field of QEEG. For example, computerised scoring programs may be used to facilitate the identification of different sleep stages (Broughton, 1993) and to detect spike patterns associated with seizure disorders, in the EEG record (Gotman, 1982). The fact that computer programs can now detect some of the patterns or abnormalities in Traditional EEG records, can be viewed as evidence to support the validity of the use of computerized EEG in some areas of research.

Reliability of Traditional EEG

Reliability is described by McMillan and Schumacher (1989) as "the consistency of the observations obtained through the instrument employed in the study" (p. 188). Perhaps Hans Berger conducted the first tests of reliability on Traditional EEG when he noticed that repeatedly, upon closing ones eyes, a rhythmic pattern appeared in the EEG record. Berger termed this rhythm Alpha, arguably because it was the first rhythm he was to document. In general, assessing the change produced by different passive states (eyes open, eyes closed) and active states (hyperventilation and photic stimulation) is still in use today in Traditional recordings (Gloor, 1969).

In Traditional EEG applications, reliability of the EEG record is often measured by determining the agreement between skilled raters of the same record. Demonstrating reliability of the records in this way is questionable as the evaluations are subjective and prone to human error. In other words many of the early studies which attempted to establish the reliability of the EEG were in fact judging the interrater reliability (Blum, 1954; Houfek & Ellingson, 1959; Travis & Gottlober, 1937). The confounded nature of these reliability studies may in large part have been the impetus for the development of many of the quantitative tools used in the analysis of EEG.

Reliability of QEEG: Eyes Open and Eyes Closed

The advent of computer processing allowed reliability studies to evolve beyond assessing the reliability of raters. Since the computer programs repeatedly quantified the records the same way, statistical tests could replace subjective evaluations of the EEG data. The computer algorithms are now beginning to achieve reliability approaching the standard set by inter-rater reliability with experienced interpreters.

Many studies have attempted to define the test-retest reliability of QEEG. Unfortunately, the procedures used are different in virtually every EEG study encountered. This makes comparison very difficult. As Salinsky, Oken and Morehead (1991) commented: "These studies are difficult to summarize due to differences in subject age, recording technique, test conditions, re-test intervals, analysis variables and statistical methods"(p. 382). One thing that many of these studies do have in common is the use of a test - retest model to demonstrate the stability of the EEG measures. However, a test - retest design is not universally applied in reliability studies. Some researchers have used an internal consistency model to examine differences between electrode recording sites in short intervals of EEG (Burgess & Gruzelier, 1993).

Principles associated with psychometric theory such as establishing the reliability and validity of assessment devices were applied to QEEG analysis by John, Prichep, Ahn, Easton, Fridman & Kaye (1983). This group had proposed a different approach to EEG analysis termed Neurometrics (John, et al., 1977). The principles of neurometric analysis are outlined in the 1983 paper as a process to be followed to replicate, and to utilize clinically, the principles of neurometrics. John, et al. (1983) attempted, to define how brain wave patterns for people with a variety of neurologic or psychiatric disorders differed statistically from "normal" brain wave patterns and to "provide accurate and practical methods for separating patients with cognitive impairments into those with and without quantitatively demonstrable abnormalities in brain electrical activity" (p.241). They state as a further goal, "to replace subjective judgements by objective computer extraction of quantitative features considered to be of diagnostic utility" (John, et al., 1983, p. 240).

John, et al. (1983) chose to start their work with those tasks used in Traditional EEG, thus, only eyes open and eyes closed tasks were analysed. Ultimately they selected eyes closed as more reliable in a test - retest design which evaluated power and relative power measures of EEG activity. In a further refinement of the measure, relative power was selected as the measure that resulted in the greatest stability across multiple t-tests. Power as a measure and relative measures in general, have recently been criticized by Sterman, Mann, Kaiser and Suyenobu (In Press), nevertheless John and his colleagues documented a method for validating EEG measures. A principle component of the process is first determining the reliability of the measure.

John, et al. (1983) report test - retest reliability coefficients for a learning disabled population of "about 50 children"(p. 260). Notes to the findings of John et al, include: Bi-polar derivations were utilized in this study, and "Correlation coefficients were computed between relative power values, Z-transformed relative to age regression equations (see below)[sic], obtained from repeated records of learning disabled children retested at intervals of one hour, one week, six to eight months and about two and one half years" (p. 261). The results reported by John, et al. follow a pattern similar to those seen in psychometric data, as the interval between tests gets longer the reliability of the measures tends to decrease.

Fein, et al. (1983) studied both "normal" and dyslexic children in a test - retest reliability study. The test - retest interval was five hours. In the intervening time children participated in other evaluative activities and were given lunch. Reliability was assesses with a multivariate statistical test referred to as inter class correlation (ICC) analysis. "The ICC measures the proportion of total score variance accounted for by inter-subject differences" (p. 398). Reliabilities for the normal group were very high in the .8 - .9 range. Interestingly, the reliabilities for the dyslexic group were somewhat lower.

Reliabilities in the Fein et al. (1983) study also varied by the location of the recording electrode. Lower reliabilities were reported in the temporal areas, especially for the delta (.5-3.5 c/sec) and beta, (20.5-32.5 c/sec) bands. The authors attribute the lower reliabilities in these bands and locations to the presence of movement and EMG artifact. The authors also set out an interesting "rule of thumb" fc. assessing the reliabilities of EEG parameters in the following:

> We considered EEG reliabilities acceptable if they were roughly equivalent to reliabilities of the diagnostic or psychometric variables they were to be correlated with. For this reason we arbitrarily decided that reliabilities above .70 would be considered acceptable, while reliabilities above .90 would be considered excellent (Fein, et al., 1983 p. 402).

This study used both linked ear and vertex (CZ) references.

The authors note that the linked ear reference produced consistently lower reliabilities than the vertex reference. However, since linked ears is the more commonly used reference those results are reported. Regardless of the differences in the methods and the analysis the results of this study are similar to those of John, et al. (1983).

Gasser, Bacher and Steinberg (1985) recorded eyes closed EEG from 26 normal children (mean age of subjects 12.2 years) who were being used as controls for a separate study. Ten months later the subjects were retested (mean age of subjects 13.0 years). The sample consisted of ten male and sixteen females. A linked ear reference was used to collect twenty seconds of artifact free data from each subject. Results are reported for absolute power after the data were corrected for the effects of eye movement artifact (EOG) using a method established by Gasser, Sroka and Mocks (1985).

Once again, although there are differences in the population, methodology and analysis the results are consistent with those reported by John, et al. (1983). The one exception is that the absolute and relative measures of power in this study did not differ significantly. Remember that John, et al. chose relative over absolute measures when they demonstrated differences in the reliability of the two measures. Gasser, Bacher and Steinberg (1985) note that artifacts likely led to lower reliability coefficients for the delta band, especially in anterior (frontal) sites. This study also re-affirmed the selection of twenty second of artifact free EEG as a good estimator of reliability. Twenty seconds of data had been suggested as a safe minimum for analysis by Mocks and Gasser (1984).

These studies are a representative sample of the reliability studies carried out with eyes open and eyes closed QEEG. As noted, there are differences in the methods and the populations analyzed. While it is difficult to directly compare the numeric data in each study, the reliabilities reported remain relatively constant (about .75 -.9) depending largely on the retest interval. Eyes closed is usually the more reliable of the measures, perhaps because of the predominant alpha rhythm that normally appears in the eyes closed record.

Two Distinct Uses of QEEG

QEEG has been used to define differences between populations of people with different disorders. Examples of this work can be seen in the work of Jansen, 1992; John, et al., 1977; Itil, Saletu, Davis and Allen, 1974; Mann, Lubar, Zimmerman, Miller & Muenchen, 1990 among others. The comparisons between groups is undertaken in an effort to define a pattern of brain wave activity associated with a disorder. This work has been carried out with both eyes closed and on task EEG recording.

QEEG has also been applied in the investigation of differences in the brain areas involved in the completion of certain "higher cortical functions", as Gevins and Schaffer (1980) termed "tasks". In this type of study groups of people (both normal and pathological have been used) are assessed while completing different cognitive tasks, then the results are compared to the same group of subjects participating in either a rest task, or a task thought to require activation of different cortical areas see Gevins, Zeitlin, Doyle, Schaffer, and Callaway (1979) and Sterman, Mann, Kaiser & Suyenobu (In Press), for examples of this research design.

While these uses of QEEG are not opposing they do represent two distinct research designs both of which may employ cognitive tasks. The use of cognitive tasks while recording QEEG data will be referred to as "on task" EEG.

<u>On Task EEG</u>

Gevins, et al. (1981) and Gevins, Zeitlin, Doyle, Schaffer and Callaway (1979) describe cognitive tasks utilized while recording EEG. There were many variables that their research attempted to control including motor and eye movement, task difficulty and handedness. Tasks were presented with a slide projector and designed to allow yes or no answers. The subjects responded to by pressing a button. The findings indicate that the Beta (16-20 Hz) and Alpha (undefined in their paper, but classically defined as 8-12 Hz) amplitudes on average dropped by some 10% from the eyes open (EO) control condition to the cognitive task. Theta amplitudes appeared to increase at the same time. Though there is not a significant change reported in the test - retest reliability for theta, theta amplitudes rising when the task is introduced is consistent with results reported by Janzen, Graap, Stephanson, Marshall and Fitzsimmons (In press) for on task EEG.

Those who did not attain 80% accuracy on the tasks were excluded from the EEG analysis portion of this study. It is important to note that this study sought to demonstrate different areas involved in the tasks presented thus, those who did not achieve the required accuracy could not as the process they used to arrive at the results may not have been consistent with those who successfully completed the task. Thus, by including the brain wave patterns of those who have not successfully completed the task in the statistical analysis with the patterns of those who successfully completed the task the results may have been confounded.

Galin, Johnstone and Herron (1978) report on reading, writing and block design tasks. This study attempted to control for the difficulty of each task by analyzing the amount of time it took to complete each task and asking the subjects to subjectively rate each task for difficulty. Unfortunately, this study uses only the alpha band and four EEG channels referenced to CZ to determine the EEG effects of task difficulty.

These studies represent examples of on task EEG recording. But perhaps more importantly, these studies introduce several variables that are important when cognitive tasks are introduced into EEG research. The first set of variables are artifacts associated with specific the tasks performed during recording. The second set of variables are associated with task difficulty or the ability of the subjects to perform the task. Indirectly, engagement and attention must also be implicated as it is possible that the task difficulty causes those subjects who cannot complete the task to become frustrated and simply give up. If this were the case, these subjects might not be performing tasks associated with the study and thus including their brain waves could introduce a confounding variable into the study.

Reliability of On Task EEGs

In addition to the variety of different ways for assessing reliability there are also a variety of 'cognitive' tasks used in the assessments. Most studies use either an eyes open or an eyes closed baseline measure, (Burgess & Gruzelier, 1993; John, et al. 1983; Oken & Chiappa, 1988) but there is little agreement among researchers as to the other tasks.

Burgess and Gruzelier (1993) examined the "spatial distribution" (p.219) of the EEG within a subject over time. This study utilized an eyes open condition and "simple motor task" (p. 219) during the data acquisition, namely the "Luria finger opposition task" (p. 220) to activate a subjects cognitive function. This task involves touching each finger on the hand with the thumb sequentially.

Burgess and Gruzelier defined "spatio - temporal reliability as "the extent to which the distribution of EEG amplitude over the scalp at different electrode sites remains constant over time given the same recording conditions" (p. 219). This study found "generally high reliabilities suggesting a high degree of internal consistency" (p. 221) among the electrode sites for each task. Others have demonstrated moderate to high intercorrelations among electrode sites (John & Prichep, 1993). Chronbach's coefficient alpha was reported to describe the internal consistency of the EEG recording sites in this study.

Burgess and Gruzelier (1993) utilized an electro cap for placement of the electrodes and a linked ears reference. At least twenty seconds of "relatively artifact free EEG recordings were obtained in both the activation conditions and at least one of the baseline conditions" (p. 220), this is consistent with the guidelines suggested by Mocks and Gasser (1985).

Oken and Chiappa (1988) defined reliability in terms of the short term variability "over a period of minutes" (p.192). Their findings suggest that the EEG does vary significantly in a short period of time (2 minutes), though their study is cited as demonstrating that "relatively small variations occur within a single two minute recording condition, though some individuals showed wide variation...."(Burgess & Gruzelier, 1993, p. 219).

Oken and Chiappa (1988) compared eyes closed data to data recorded while listening to a story (also with eyes closed). Data were recorded in bi-polar and ipsalateral ear reference montages. Results are reported in terms of test-retest differences, the difference between even and odd epochs and the coefficient of variation (CV). CV is calculated by the "ratio of the standard deviation to the means of a number of EEG epochs" (Oken and Chiappa, 1988, p. 191). The reader is referred to Oken and Chiappa (1988) for a complete list of results as this type of analysis is not to be performed here.

Level of arousal is suggested as a variable which changes the EEG pattern by Gevins, Zeitlin, Doyle, Schaffer, and Callaway, (1979) and by Salinsky, Oken and Morehead (1991). Therefore, uncontrolled changes in arousal could account for some of the variation in reliability reported by Oken and Chiappa (1988). Salinsky, Oken and Morehead (1991) used "an auditory choice reaction time task to help stabilize the state of alertness and minimize test-retest differences due to early drowsiness" (p. 382). They suggested better reliabilities would result if the task was structured, as opposed to unstructured as the level of alertness could be better controlled.

Of note in the results is the statement that "many features were less reliable in the mid temporal channels T3 and T4" (p.386). Additionally, the authors note that "most correlation coefficients had lower values for the 12-16 week interval as compared with the 5 min interval" (p.387). This is consistent with the findings of John, et al, (1983) for eyes closed data. The authors also note that the reliabilities obtained with the adult population they studied were somewhat higher than those obtained in studies employing children (Fein, et al. 1983; Gasser, Bacher & Steinberg, 1985; John, et al. 1983) and speculate that development in children adds to the variability of their EEG measures. Whether development or other intervening variable are to blame remains unresolved. It is important that reliabilities comparable to those seen in eyes closed recordings were obtained while subjects performed a task.

Hawkes and Prescott (1973) recognized the importance of controlling for level of arousal when they adopted several different counting and alerting tasks for a reliability study of adult population mean age 30 years (range 19-59). The sample consisted of sixteen males and eleven females. Unfortunately, this study only looks at one recording sited described only as "the right temporo-occipital area" (Hawkes & Prescott, 1973, p. 197). The authors note that "In order to make valid comparisons of serial EEG it is important to maintain the subjects at a constant level of attention" (p. 198). Again, the age of the subjects is not critical but rather that the level of attention be maintained in both recordings.

Along with the level of arousal there are a variety of other technical and procedural guidelines which are relevant to the completion of this study.

<u>Rationale for Procedures</u>

Controlling attention and arousal are the primary reasons that tasks were included in the previous reliability studies. In general, tasks produced reliabilities that were not significantly different from the reliability of eyes closed data. The tasks presented are generally quite simple, though more complex tasks were discussed in the previous section. There seems to be a lack of studies which examine the reliability of rather complex cognitive tasks.

Gevins and Schaffer (1980) have been critical of research which does not attempt to control for artifact and of research which employs tasks which produce artifact. The tasks employed in this study, namely reading and drawing are likely to induce artifact, especially eye movement artifact. This artifact should generally be random and is readily identifiable in the record. Every effort was made to both reduce the artifact during the task recording and to eliminate any epochs containing artifact from data analysis. Remember, Mocks and Gasser (1984) suggested that twenty seconds of artifact free data is the minimum required for analysis.

It is also important to note that this research was not concerned with identifying areas of the cortex activated by the task presented as Gevins and Schaffer (1980) were, but rather, to determine if the tasks resulted in a repeatable pattern of EEG activity based upon a general arousal. Also of note is the finding of Mocks and Gasser (1984) when they note "....that the choice of criterion for selecting epochs of EEG for quantitative analysis is less crucial than anticipated. This lack of sensitivity is an asset since it [sic] is in favour [sic] of a rather good comparability of results between laboratories using different selection and rejection rules" (p. 91).

The EEG effects of task difficulty have also been researched (Galin, Johnstone and Herron, 1978). These authors introduce the possibility that task difficulty may lead to increased asymmetry between the alpha activity recorded from the left and right sides of the head. This led to the selection of tasks that were thought to represent roughly the same level of difficulty for this study. As pointed out by Donchin, Kutas and McCarthy (1977) however, subjective estimates of task difficulty are less valuable that actual performance measures which are associated with the difficulty level. For example, tasks that allow timing of the response, or objective scoring of questions would be considered more useful in objectively defining the task difficulty. Gevins and Schaffer (1980) go as far as to exclude those who do not perform up to a pre-established criterion. This research did not obtain performance measures for each task, but again we are not trying to differentiate the brain areas activated by the individual tasks. Because this research is not concerned with the isolation of task related EEG to a particular site, channels are selected for analysis for different reasons.

The following channels were selected from among the nineteen recorded for additional analysis: FZ, CZ, PZ, C3, C4, P3, P4. These channels were selected for the distance from artifact generating sources (muscles and eyes) and for there potential involvement in the attentional process to be analysed. Lubar (1991) Mann, Lubar, Miller, Zimmerman and Muenchen (1990), Jansen (1992), Sterman, Mann, Kaiser, and Suyenobu (In Press) have implicated these sites in the process of attention. Additionally, the first five sites are being utilized in training children at the University of Alberta Cognitive Re-regulation Program.

As an aside, it is worth noting that channels labled with odd numbers correspond with sites on the left side of the head. Those channels with even numbers correspond to right side locations and the channels labled with "Z" in the name are over central locations. All placements were in accordance with the international 10-20 system (Jasper, 1958).

Reading, drawing, math and listening tasks are used to demonstrate difference between the two groups of subjects as suggested by Lubar (1991) and Mann, Lubar, Miller, Zimmerman and Muenchen (1990). Data from Jansen, Graap, Stephanson, Marshall and Fitzsimmons (In Press) suggest that the reading and drawing tasks produced larger differences between Attention Deficit Disorder (ADD) and normal control groups. Though these tasks have been studied using QEEG, there appears to be a lack of studies supporting the reliability of these EEG measures taken while subjects perform these tasks. Thus, the present study is undertaken to examine the test - retest reliability of the reading and drawing tasks.

Research Questions

In this study, the first question was to establish if eight day test - retest reliability of on task EEG using reading and drawing tasks were comparable to previous reliability assessments of eyes open and eyes closed conditions. The second question was to establish preliminary test - retest reliability figures for individual recording sites in a population of 9 to 12 year old boys, with the Lexicor NRS-24. The third question was to determine general trends in the data resulting from average reliabilities across both recording sites and broad band parameters. It was expected that the on task reliabilities would be comparable to those found using other tasks and the eyes open and eyes closed conditions.

Chapter 3

Methods

Sample

Initially this study was to be limited to right handed boys, thus each of the twenty five fifth and sixth grade right handed males from an Edmonton area public school was invited to a group orientation about this research project. At this time the purpose and goals of the research were explained. Additionally, they were familiarized with some of the materials to be utilised in applying the EEG cap. At the end of the orientation, packages of information were offered to those who wished to have them.

The package of information included a description of the study being carried out, an informed consent form (which included permission to examine the child's school records), and a history form (see Appendix A, B, C for copies of forms). Interested boys were encouraged to bring the information to their parents and if appropriate have their parents complete all of the necessary forms. They were given a deadline of three days to return the forms if they wished to participate.

All subjects were required to present completed informed consent and history forms prior to any testing. Fourteen of the original twenty five right handed boys who met the criteria for inclusion in the study volunteered to participate. One boy came down with the chicken pox on the first day of the study and was eliminated from the sample. As he was never assessed, his completed consent and history forms were destroyed.

The four left handed subjects were recruited after the study had started. These boys were recruited by re-visiting the classrooms and expanding the criteria to include left handed boys who met the age requirements of the study. More information packages were passed out and four additional subjects agreed to participate. All of the left handed boys were oriented to the equipment and procedures individually at the time of the initial assessment.

Ultimately, the sample consisted of thirteen right handed and four left handed males. All subjects were between the ages of 122 and 144 months (10 - 12 years). Fein, Galin, Yingling, Johnstone and Nelson (1984) suggest that the EEG spectra in males is developmentally stable across the ages of nine to thirteen years.

None of the subjects were taking any medication during any part of the testing. All subjects indicated that they had rested and they had eaten meals on their regular schedules prior to testing. Each subject was enroled and attending school in the regular fifth or sixth grade classroom.

During the course of the study, it became apparent that the subjects were communicating with each other about the recording sessions. Subjects assessed later in the study seemed to know what was going to happen and often spoke of the "neat things" their friends had seen and done. This was thought to aid in producing a generally relaxed atmosphere during the assessment. All subjects seemed comfortable with the process they had volunteered for upon arrival in the recording room. Allowing subjects to play computer video games while preparations for recording were completed also may have helped them feel at ease with the situation.

Psychometric Testing

Sixteen of the seventeen children had taken the Canadian Achievement Test (CAT) (Canadian Test Centre, 1992) in the year prior to participation in this study. Permission to examine school records was obtained, and scores from the previous testing were obtained from school officials a summary of these scores is reported in chapter four.

In addition to the CAT results, the Canadian Test of Cognitive Skills (CTCS) Level 2 (Canadian Test Centre, 1992) was administered to each subject. This testing was carried out 5 weeks after the data acquisition was completed.

During the study, one of the each subject's parents and the subject's primary classroom teacher completed the Parent/Teacher Rating Scale (SNAP) (Swanson, Nolan & Pelhin, 1981). This scale is thought to help distinguish between those children with and without attention disorders. Results are discussed in chapter four.

It is important to note that no subjects were disqualified from any portion of the study based upon their scores on the psychometric tests.

Preparation for Recording

All recordings were conducted at the school, during school hours (approximately 0830 to 1530 hours). Each subject attended two recording sessions lasting approximately 1.5 hours eight days apart.

Upon entry into the recording room, each subject was introduced to all staff present. The purpose of the research was briefly outlined and all subjects were familiarized with the equipment to be utilized in the research. Once these tasks were accomplished, the subjects were allowed to play computer games while preparation for data acquisition proceeded.

Equipment

Nineteen channels of EEG data were collected utilizing the NeuroSearch-24 (NRS-24) from Lexicor Medical Technology, Inc. (Boulder, CO) and the Electrocap (Electrocap International, Eaton, OH). The Electrocap places the electrodes according to the international 10-20 system (Jasper, 1958). Electrodes were applied using Electrogel (Electrocap International, Eaton, OH) and all impedance measured below 5K ohms. Impedance was checked at the beginning, generally the middle and at the end of each recording session. All recordings were referenced to linked ears.

Settings for the NRS-24 were as follows: Sampling Rate = 128 samples per second (SPS); Gain = 32000; High Pass Filter = .5 Hertz (Hz); Low Pass Filter = 32 Hz. All of the EEG data was recorded to the computer hard disk and later transferred to backup tape. Files were coded to allow identification of the subject, the task and the time of the recording.

Artifact Training for Subjects

When preparations for data collection were successfully completed, subjects were shown their brain waves on the computer screen. Each was instructed in creating common artifacts such as: eye movement, jaw muscle tension, swallowing and motor movement in order to demonstrate the effect of these activities on the EEG signal. Each subject was asked to limit the amount of artifact that they produced during the recording session. If there were particular areas of muscle tension identified, attempts to alleviate this artifact were made. This included progressive relaxation techniques, alternately tensing and relaxing muscles, placing ones fingers gently upon the closed eye to feel eye movement or other strategies deemed appropriate. All efforts were directed toward removing as much artifact as possible during the recording rather than discarding data during the analysis portion of the study.

Procedure for Recording EEG Data

Recording was conducted with the subject seated in a comfortable, adult size, padded chair. A foot pillow was provided for those who wanted it as the size of the chair precluded some of the subjects feet from reaching the ground. Each subject was seated at a table approximately 5 feet from a chalk board.

The study was conducted in a room between two first grade classrooms. The room was referred to as the "bubble" and is used as a storage area/individual instruction area by the first grade teachers. The room furniture consisted of two tables, approximately eight chairs, the recording equipment which was set upon a mobile cart, several filing cabinets and a variety of teaching materials. Sunlight entered the room through high windows located behind the recording area. The room could be darkened by drawing all of the curtains. Occasionally noise from the adjacent first grade classrooms could be heard, and recording was subject to some interruptions from teachers, school personnel, recess bells and public announcements from the office. Generally, the recordings progressed without interruption.

The first four tasks (eyes open, eyes closed, reading and drawing) were constant in both the first and second recording sessions. The last two tasks of the first session and the last task of the second recording session were different. These tasks were recorded in support of other ongoing research and will not be discussed further here.

Retest Interval

Fifteen of the seventeen subjects were recorded at the same time of the day eight days after the initial recording, in an attempt to control for differences in alertness caused by the circadian rhythm. Two subjects were recorded 1.5 hours later in the day for their second recording session, in order to accommodate their school schedules. In general all procedures associated with preparation of the subject, recording of data and clean up were accomplished in less than 1.5 hours.

Length of Each Task

All tasks were recorded until five minutes of data were obtained. In some cases individual subjects were asked to repeat sections of the reading or drawing tasks in order to provide five minutes of data. In several cases equipment failure, due in part to static electricity, required that tasks be completely repeated. It is possible that repeating a task caused individual subjects to tire or become bored, however the recording was only for five minutes and no subject had to repeat more than one task. It would be difficult to assess the motivation of these students to miss class, but they did not seem in a rush to return to class.

Specific Information about Tasks Assessed

Tasks similar to those used for this study were described by Mann (1992) for recording from both normal and attention deficit disordered subjects. Janzen (1992) describes the actual tasks that were utilized in this study in great detail. In general, the tasks described by Janzen were employed in this study.

Eyes open

The eyes open task was recorded with the subject seated comfortably and looking at a dot drawn on the chalk board approximately 5 feet in front of them. Subjects were asked to limit the number of blinks and the amount of eye movement during this task. Frequent breaks were utilized in order to help eliminate eye movement artifacts. These breaks may have also had the added advantage of re-focusing the subjects on the task at hand and thus may have resulted in a more accurate representation of the task. Short tasks have been proposed by Gevins and Schaffer (1980) as one way to control for arousal and alertness fluctuations.

Eyes closed

The eyes closed task was accomplished in a darkened room. Subjects were asked to keep their eyes directed toward the dot that they now could not see. On most cases cotton balls were applied to the eyelids of the subjects to help them become aware of, and reduce their eye movements. Generally, recording progressed for the full five minutes in this task without interruption.

Reading

The reading task was comprised of reading stories, (approximately one page in length) selected from the CAT, levels 14, 15 and 16. Each subject had the paragraph held in place before them so that they would not have to move their arms or hands to hold it. The material was placed at eye level in order to minimize the need for head movement and to lessen neck tension. Lighting was provided by overhead florescent lights. Each subject was asked to read the first paragraph of the first story aloud to assess their ability to read the material. They were also instructed that they would be asked questions about the stories when they had finished reading them.

Recording was paused at the end of each story and questions were asked about the content of the stories. Generally, comprehension of the material was adequate to indicate that the subject had read the material. In the rare case that a subject did not seem to understand what he had read, instructions about reading more carefully were given. It is also of note that in each record characteristic waves caused by eye movement artifact were identifiable as the subject read. This does not prove that the subject read, but it is a pattern of eye movement normally associated with reading.

There was variability in the speed at which the subjects read, however this is not thought to be relevant here as reading ability is not being assessed but rather alertness or arousal. Interestingly, most of the subjects could remember the first story that they had read in the first testing session when asked about it in the second testing session. They were generally not able to recall information from the second or third stories.

Different passages were used in the second testing. The difficulty of the passages was judged to be roughly parallel. Each child was asked to differentiate which was harder, they all indicated that there were no differences.

Drawing

Drawing was accomplished with the aide of a small angled desk placed upon the table in front of the subject. Subjects were asked to sit comfortably and to limit their movement. Subjects were asked to study each presented figure before attempting to draw it, rather than looking back and forth. This was only marginally successful, as most subjects chose to look back and forth and had to be reminded. In the first sessions the Developmental Test of Visual-Motor Integration (Beery, 1982) was utilized. In the retest, the figures from the Bender Visual Motor Gestalt test (Bender, 1938) were presented. Instructions provided for these tests were given to the subjects (Beery, 1982; Koppitz, 1975). Generally, each subject was instructed to make figures just like the ones placed before them.

In a few cases subjects were asked to re-draw figures so that five minutes of data could be obtained. With two people administering the task the EEG recording system was paused when pages had to be turned or there were delays in the task. Generally, the subjects completed three drawings from one page on the Beery, then the system was paused to re-orient the paper. When the Bender was being administered the task progressed with only minor delays.

The subjects seemed to like the drawing task. However it should be noted that the Beery task is designed to progress from easier designs to more complex ones toward the end of the task. This characteristic differs from the Bender which does not progress to figures of comparable difficulty (particularly the three dimensional figures) and thus may have led to poor comparability in the data.

At the outset the two tests were chosen as they were thought to be roughly parallel in difficulty. This assumption may not have been completely valid.

Data Analysis

Data were artifacted visually as soon after the completion of a recording session as possible. Artifacting was carried out by persons experienced in the analysis of QEEG. Each days recordings were artifacted prior to the end of the day. Artifacted data were then saved to magnetic tape. Reports of the average magnitude of the signals in defined bands were obtained from the Lexicor Software. The following bands were used in the Lexicor Software to analyze the data:

Table 3.1
Definition of Frequency (Freq) Bands used for analysis

Band Name	Start Freq	End Freq
Delta	0	4
Theta	4	8
Alpha	8	12
SMR	12	16
Beta1	16	20
B_All	12	20
EMG	24	32
Total	.5	32

Note: The way the Lexicor software is written the bandwidths do not overlap. $F_{lower} < F <= F_{upper}$ (Lexicor, 1990,p.8-32)

Upon generation of the reports in average magnitude (microvolts), a text editor was used to format the data for analysis with spread sheet and statistical programs. The following channels were selected from among the nineteen recorded for additional analysis: FZ, CZ, PZ, C3, C4, P3, P4. These channels were selected for distance from artifact generating sources (muscles and eyes) and for potential involvement in the attentional process to be analyzed.

Only a subset of bands were chosen for further analysis as well. The bands defined as delta and EMG were deleted from further consideration as they are thought to be primarily made up of artifact.

Formatted reports were imported into several different programs for statistical analysis. The primary analysis performed was the Spearman Rank Order Correlation. The correlation was run for the same bands and the same tasks for test one and test two. For example, average theta amplitude for each subject on test one for drawing was correlated with average theta amplitude for each subject on test two drawing. Of primary interest was whether the subjects remained in relatively the same position based upon the average amplitude of a particular frequency produced.

Chapter 4

Results

Age of the Sample

The age of the sample averaged 134 months (11 years 2 months) (SD 6.18 mo). The ages of the subjects ranged from 122 to 144 months. The ages of the subjects are within the age range suggested to be stable by Fein, Galin, Yingling, Johnstone and Nelson (1984).

Retest Interval

Test - retest interval averaged 8.1 days (SD=2.0) for all subjects. The shortest retest interval was seven days and the longest interval was 14 days. It was felt, at the time, that it was more important to hold the rest of the subjects as close to the proper schedule so those who missed schedule due to school commitments were rescheduled at the next available time slot corresponding to the original test time.

15 of the 17 subjects were tested at the same time of day on the re-test. Two boys were re-tested 1.5 hours later in the day.

Psychometric Results

Canadian Achievement Test

Achievement scores from the CAT were available from the school. A summary of the subjects percentile ranks for the total test battery are reported here. The minimum percentile earned by a subject was 17 and the maximum was 99. One child was not in this school system last year therefore no score was available for subject 12.

The results suggest that the sample is about average in terms of achievement. There were several individual subtest scores that may indicate specific problems associated with learning for two of the subjects. One subject had a fourth percentile score in the reading area, while another had a fourth percentile score in the math area. Given that the study was not controlling for learning difficulties, the two boys were retained in the sample. While two boys were having difficulties there were two other boys who are at or near the top of the academic performance range. Overall achievement scores in the 99th and 96th percentiles were received by two other subjects included in the study.

SNAP

The results of the SNAP were analyzed using a criteria of greater than two standard deviations above the published norms for clinical significance. Only one subject, in only one scale, met the criteria for clinical significance. As there was little supporting evidence for dropping this subject form the sample, he was retained.

Reliability of EEG Assessments

For all of the results that follow the sample size for the eyes open (EO), eyes closed (EC) and reading (RD) tasks is seventeen. Reliability of drawing (DR) is based upon a sample size of sixteen. In the second test, data for subject 12, drawing was lost. Subject 12 was not included in the analysis of the reliability of the drawing task, but was included in all of the other analyses.

Visual artifacting was completed on all data prior to analysis. At least 26 seconds (13 epochs) of data were included for each subject, in each task. On average 69 epochs (SD_{pooled}=15.5) were included for the eyes open task, 70 (SD_{pooled}=17.6) for the EC task, 51 (SD_{pooled}=13.7) for the RD task, and 41 (SD_{pooled}=10.2) for the DR task. There was a significant difference in the number of epochs included from the passive to the active tasks as determined by multiple T-tests.

Table 4.1
Average Number of Epochs Included by Task

Task	AVG 1	STD 1	AVG 2	STD 2
EO	70	16.3	68	14.7
EC	68	16.8	72	18.4
RD	54	14.8	49	12.6
DR	39	11.9	43(a)	12

Note: EO=eyes open, EC=eyes closed, RD=reading, DR=drawing
(a) N=16, all others N=17

There were no significant differences between number of epochs included in the analysis when examining the same task on the occasions of test one and test two. There were significant differences ($p<.05$) between EO when compared with RD, and EO when compared with DR during both test 1 and test

2. There were also significant differences ($p<.05$) between EC when compared with RD, and EC when compared with DR during both tests.

<u>Reliability by Channel</u>

Results of this study were calculated using average micro-volts as reported by the Lexicor software program. Reliability values were calculated using Spearman rank order correlations and are reported for each task. This approach likely yields a more conservative estimate of the reliability than a straight Pearson product moment correlation.

In order to speak about the results in a meaningful way, some basic guidelines seem appropriate. In order for a correlation to be significantly different from zero, the number of subjects and the alpha level must be determined. Additionally, one must decide if the test is to be directional (ie. one tailed) or nondirectional (ie. two tailed) (Glass & Hopkins, 1984). The expected correlation between test one and test two in this study is quite high, in the .8 range, therefore a directional (one tailed, $alpha_1$) test was chosen to test the hypothesis that the test - retest correlation is equal to zero (ie $H_0: r_{test.retest}=0$). The .01 alpha level was chosen for comparison.

The number of subjects (N) for the EO, EC and RD tasks was 17, while the N for the DR task was 16. This results in different critical values for the correlation for the different tasks. The critical value for testing H_0 is .582, where $N=17$ and $alpha_1=.01$ and the critical value when $N=16$ is .601 (adapted from Glass and Hopkins, 1984, p.550).

Table 4.2
Reliability Coefficients for Channel FZ

Task	Theta	Alpha	SMR	Beta1	B_All	Total	Avg
EO	.49	.51	.62*	.67*	.72*	.47	.50
EC	.68	.82*	.72*	.58	.65*	.72*	.70*
RD	.81*	.54	.75*	.69*	.73*	.75*	.71*
DR	.76*	.35	.82*	.69*	.72*	.45	.63*

Notes: EO=Eyes Open, EC=Eyes Closed, RD=Reading, DR=Drawing
Drawing task N=16, all other tasks N=17.
* $p < .01$

Of note in Table 1 are two low values associated with the EO task. The Theta, and Total bands have lower reliability coefficients than expected for this task. The lowest reliability coefficient reported for all of the channels analysed occurs in the alpha band during the drawing task. 19 of the 28 coefficients were statistically different form zero.

This channel was the only time that the average reliability (across bands) is lower for EC than the other tasks. There are other instances that the reliabilities are equal to the EO task (see table 4.6 and table 4.10), but this is the only case where one of the cognitive tasks averaged higher reliability than EC.

There are no high values (greater than .85) in Table 1. This tends to confirm expectations of lower reliability for sites in the frontal areas. One might expect lower reliabilities because of the proximity to the eyes and the frontalis muscles, both generate artifact in the EEG record.

Table 4.3
Reliability Coefficients for Channel CZ

Task	Theta	Alpha	SMR	Beta1	B_All	Total	AVG
EO	.71*	.82*	.64*	.74*	.80*	.74*	.74*
EC	.77*	.66*	.88*	.78*	.85*	.80*	.79*
RD	.68*	.79*	.75*	.75*	.80*	.80*	.76*
DR	.46	.61*	.74*	.63*	.75*	.58	.63*

Notes: EO=Eyes Open, EC=Eyes Closed, RD=Reading, DR=Drawing
Drawing task N=16, all other tasks N=17.
* $p<.01$

In table 4.3 the particularly low value for the Theta band during the drawing task is difficult to explain. Reliabilities for the theta band, during the drawing task, do not appear to be consistent with the other tasks. Twenty six of the 28 coefficients are statistically greater than zero.

Table 4.4
Reliability Coefficients for Channel PZ

Task	Theta	Alpha	SMR	Beta1	B_All	Total	Avg
EO	.74*	.82*	.67*	.78*	.70*	.65*	.73*
EC	.73*	.71*	.66*	.81*	.73*	.74*	.73*
RD	.65*	.83*	.51	.81*	.77*	.56	.69*
DR	.56	.50	.73*	.69*	.85*	.52	.64*

Notes: EO=Eyes Open, EC=Eyes Closed, RD=Reading, DR=Drawing
Drawing task N=16, all other tasks N=17.
* $p<.01$

The low value for alpha during the DR task is interesting as Alpha is generally classified as a posterior phenomenon, and one might expect that it would become more reliable closer to the posterior portion of the head. Twenty three of 28 coefficients are statistically greater than zero.

This value in the B_All band during the drawing task

(.85) is one of the highest values reported for the drawing task in among all of the channels and bands examined. This area of the cortex is not usually associated with the drawing task therefore these results are somewhat surprising.

Table 4.5
Reliability Coefficients for Channel C3

Task	Theta	Alpha	SMR	Beta1	B_All	Total	Avg
EO	.49	.84*	.62*	.73*	.69*	.66*	.67*
EC	.81*	.69*	.74*	.77*	.81*	.82*	.77*
RD	.74*	.79*	.61*	.72*	.70*	.67*	.71*
DR	.42	.45	.56	.57	.57	.54	.52

Notes: EO=Eyes Open, EC=Eyes Closed, RD=Reading, DR=Drawing
Drawing task N=16, all other tasks N=17.
* $p<.01$

Of note in this table are the low values in the Theta and Alpha bands for the DR task. The lowest average reliability, .52 (averaged across bands) for any channel analyzed occurs during the drawing task. Additionally, the Theta band in the EO condition has lower than expected reliability. It is notable that 13 of the subjects were right handed and this is a left central site which is sometimes associated with the motor area of the cortex, perhaps this has led to a decrease in the variance between subjects in this area. Twenty of 28 coefficients are significantly greater than zero.

Table 4.6
Reliability Coefficients for Channel C4

Task	Theta	Alpha	SMR	Beta1	B_All	Total	Avg
EO	.79*	.96*	.69*	.83*	.86*	.79*	.82*
EC	.81*	.88*	.84*	.89*	.80*	.87*	.85*
RD	.74*	.83*	.87*	.80*	.87*	.70*	.80*
DR	.65*	.60	.75*	.75*	.79*	.76*	.72*

Notes: EO=Eyes Open, EC=Eyes Closed, RD=Reading, DR=Drawing
Drawing task N=16, all other tasks N=17.
* p<.01

The single highest reliability reported (.96) occurs in the Alpha band during the EO task. Interestingly, there is a marked difference between these results and the results of the contra-lateral channel C3, as 27 of 28 tests here are statistically greater than zero.

Table 4.7
Reliability Coefficients for Channel P3

Task	Theta	Alpha	SMR	Beta1	B_All	Total	Avg
EO	.74*	.84*	.68*	.72*	.73*	.74*	.74*
EC	.81*	.88*	.83*	.89*	.86*	.90*	.86*
RD	.71*	.84*	.64*	.65*	.70*	.72*	.71*
DR	.86*	.61*	.63*	.71*	.75*	.63*	.70*

Notes: EO=Eyes Open, EC=Eyes Closed, RD=Reading, DR=Drawing
Drawing task N=16, all other tasks N=17.
* p<.01

There are no low reliabilities in this table 28 of 28 coefficients are statistically greater than zero. This is surprising because this channel is adjacent to channel C3 on the left side, which had some of the lowest reliabilities reported.

This table contains the highest average reliability for EC (.86), and the highest reliability for the Total band (.90). Both occurring during the eyes closed condition.

Table 4.8
Reliability Coefficients for Channel P4

Task	Theta	Alpha	SMR	Beta1	B_All	Total	Avg
EO	.78*	.91*	.82*	.78*	.76*	.68*	.79*
EC	.82*	.81*	.69*	.85*	.81*	.78*	.79*
RD	.75*	.79*	.74*	.78*	.73*	.69*	.75*
DR	.65*	.50	.83*	.79*	.89*	.66*	.72*

Notes: EO=Eyes Open, EC=Eyes Closed, RD=Reading, DR=Drawing
Drawing task N=16, all other tasks N=17.
* $p<.01$

These results are comparable to those found at location C4. The relative stability of Beta1 in the EC condition is somewhat surprising as Beta1 is not usually associated with EC. Twenty seven of 28 coefficients are statistically greater than zero.

In this section the reliability coefficients associated with individual channels have been examined. This analysis has led to some interesting findings such as adjacent channels with dramatically different reliabilities (C3 & P3) and very similar results in other adjacent channels (C4 & P4). The attenuating influence of artifact on the reliability coefficients may be one explanation for the lower values seen in table 4.2.

Reliability by Task

It is also worth examining the reliabilities of different bands averaged across the different recording sites, within a task. When ever the data are reduced further there is the danger of loosing the meaningfulness of the reliability coefficients.

Table 4.9
Eyes Open (EO) task averaged, by band, across channels

Channel	Theta	Alpha	SMR	Beta1	B-All	Total
FZ	.49	.51	.63	.67	.72	.47
CZ	.71	.82	.64	.74	.80	.74
PZ	.74	.82	.67	.78	.70	.65
C3	.49	.84	.62	.73	.69	.66
C4	.79	.96	.69	.83	.86	.79
P3	.74	.85	.68	.72	.73	.74
P4	.78	.91	.82	.78	.76	.69
Average	.68	.82	.68	.75	.75	.68
Std Dev	.131	.144	.068	.052	.061	.104

Note: N=17, Std Dev is calculated between subjects.

The alpha band has the best average reliability in the EO task. This is somewhat surprising as the Alpha band is usually associated with the eyes closed condition. The average reliabilities reported for the eyes open condition are somewhat lower than those reported for the eyes closed condition, which follows.

Table 4.10
Eyes Closed (EC) task averaged by band across channels

Channel	Theta	Alpha	SMR	Beta1	B_All	Total
FZ	.68	.82	.73	.58	.65	.72
CZ	.77	.66	.88	.78	.85	.80
PZ	.73	.71	.66	.81	.73	.74
C3	.81	.69	.74	.77	.81	.82
C4	.81	.88	.84	.89	.80	.87
P3	.81	.88	.83	.89	.86	.90
P4	.82	.81	.69	.85	.81	.78
Average	.78	.78	.77	.80	.79	.80
Std Dev	.053	.091	.083	.107	.074	.065

Note: N=17, Std Dev is calculated between subjects.

The Alpha band did not present the best reliability during this task. This is surprising as alpha is usually associated with the eyes closed task. Though the difference in the reliability coefficients could simply be due to chance.

Table 4.11
Reading (RD) task averaged by band across channels

Channel	Theta	Alpha	SMR	Beta1	B_All	Total
FZ	.81	.54	.75	.69	.73	.75
CZ	.68	.79	.75	.75	.80	.80
PZ	.65	.83	.51	.81	.77	.56
C3	.74	.79	.61	.72	.70	.67
C4	.74	.83	.87	.80	.87	.71
P3	.71	.84	.64	.65	.70	.72
P4	.75	.79	.74	.78	.73	.69
Average	.73	.76	.69	.74	.76	.70
Std Dev	.052	.105	.115	.061	.062	.075

Note: N=17, Std Dev is calculated between subjects.

From table 4.11 the Alpha and B_All bands were the most reliable during the RD task. There is generally a slight decrease in all of the bands from the eyes closed condition. While the decreases are not large they appear to be consistent. The decrease in the lower band (theta) might be anticipated due to increased eye movement artifact in the record however, the decreases in the faster bands (SMR & Beta1) are not readily explainable.

Table 4.12
Drawing (DR) task averaged by band across channels

Channel	Theta	Alpha	SMR	Beta1	B_All	Total
FZ	.76	.35	.82	.69	.72	.45
CZ	.46	.61	.74	.63	.75	.58
PZ	.56	.50	.73	.69	.85	.53
C3	.42	.45	.56	.57	.57	.54
C4	.65	.60	.75	.75	.79	.76
P3	.86	.61	.63	.71	.75	.63
P4	.65	.50	.83	.79	.89	.66
Average	.62	.52	.72	.69	.75	.59
Std Dev	.157	.098	.098	.073	.107	.114

Note: N=16, Std Dev is calculated between subjects.

The B_All band was the most reliable in the DR task. Alpha which previously had the highest reliability coefficient became one of the lowest. The decrease in all reliability coefficients from the reading task, and large differences from the eyes closed task may be indicative of unreliability associated with the task itself or of the placement of this task relative to the others as it was performed last.

Chapter 5

Discussion

General Discussion

Results

The results reported here add support to those previously reported by John, et al. (1983), Fein, et al. (1984) for the eyes closed conditions. The eight day test - retest reliability coefficients reported here are comparable to those reported elsewhere.

This also lends support to the use of the Lexicor Neurosearch-24 for further research. Recordings done with this equipment appear to be comparable, in terms of test - retest reliability, to those done with equipment from other manufacturers.

This study extends knowledge in the area of on task EEG. There were no previous studies of the reliability of EEG measures while subjects were reading and drawing. The findings of this study are consistent with the observations of Fein, et al. (1984) who observed that reliabilities decreased in sites where artifact is more prevalent. It should be noted that Fein, et al. were speaking of the temporal sites, however they were not using tasks which required eye movement, such as the reading task performed here.

Findings are also consistent in terms of the decrease in reliability when other tasks are introduced. John, et al (1983) selected eyes closed (over eyes open) as the most reliable state. Eyes closed was also found to be the most reliable state here.

The recording configuration did not seem to change the reliability estimates. Remember, others have used bi-polar montages or vertex references as opposed to the linked ear reference applied in this study. As noted earlier it does not seem to matter which recording method is used the results are quite comparable.

There was some surprise as to the variation of the reliability across sites. Values range from a low of .35 to a high of .96. Overall the only pattern that was readily identifiable was a slight decrease in the reliability from eyes closed to reading and a further small decrease during the drawing task. As will be discussed later the decrease when drawing may be related to the task not to the EEG measures.

Perhaps it is not surprising that with the introduction of reading and drawing tasks the reliability would decrease slightly. There are many additional variables which must be controlled in order to make recording EEG while performing these tasks as reliable as eyes closed recording.

Methods

There were significant differences in the number of epochs remaining when comparing eyes open (EO) and eyes closed (EC) recordings against those of the cognitive tasks, reading (RD) and drawing (DR). The difference is likely due to the presence of increased eye movement artifact in the on task records.

There are several things that could be done to further reduce the artifact generated by the reading task: 1) Make the lines of text longer, but only long enough to avoid head movement; and 2) Insure that the subjects are reading every word and not skimming the material. It would also be nice to obtain measures of reading speed and objective measures of comprehension to help differentiate the difficulty level for each subject.

Applicability of Findings

Mann, Lubar, Zimmerman, Miller and Muenchen (1990) and Jansen (1992) suggested that the Theta band is somehow involved in the drawing task when ADHD and ADD subjects and normals are compared. The decrease in reliability of the theta band during the drawing task may lend support to the assertion that theta plays a role in the this task. One suggestion is that as the amplitude of theta rises on task (Jansen, 1992; Mann, Lubar, Zimmerman, Miller & Muenchen, 1990). One might speculate that the amount of rise will be proportional to the amount of effort or interest generated toward the task. Thus for some, the engagement or interest was moderate leading to a relatively small change in theta amplitude, but for others the change was large. The difference in the amount of change could then lead to a relative change in position of the respondents thus decreasing the reliability.

Interestingly, the reliability of theta at P3 remained very good (.86). This might suggest that there were relatively small changes in the theta amplitude in this area during the drawing task. Caution is necessary as chance cannot as yet be ruled out as a cause of the notably higher reliability at P3.

Alpha has been implicated in the attentional process by

Ray, (1990), Ray and Cole (1985) and most recently by Sterman et al. (In Press). Perhaps, the decrease in the alpha amplitudes causes decrease in the variability of the EEG which leads to a decrease in the reliability coefficient? It could also be the case that subjects didn't pay attention as much in one of the two sessions and thus, the change in Alpha was different leading to a change in relative position.

Speculation

An analysis of the shift in the variance associated with the performance of each task might allow one to discover the areas involved in the performance of the task. If Sterman and others are correct and Alpha and Theta values change when a task is introduced, then areas that change in the direction predicted could lead to a new understanding of the neurophysiology of task performance.

It is interesting that when tasks traditionally associated with a particular band and a particular area of the cortex were performed, the reliability often appeared higher in other bands and in other areas of the cortex. This might support the notion that those areas not associated with the task retain variance and therefore appear more reliable and those areas involved in a task lose variance due to a restriction of range and therefore the reliability drops.

Perhaps it is the case that the reliability of eyes closed is higher than that of reading or drawing. An inherently unstructured task with an inherently physiological response. The unstructured task may be effected by many more variables and to a greater extent than the physiological response.

During the performance of the cognitive tasks the total microvolts went down thus, the variance within subjects goes down. This may lead to a decrease in the variance between subjects if the response was inconsistent and the reliability coefficient would be attenuated as subjects change relative positions. This may be tied to a restriction of range in the on task EEG. As areas of the cortex come into use on a task the voltage generated in the alpha band comes down (Sterman, et al., 1994). Any inconsistent decrease could lead to more relative movement between the subjects.

The reliability could be lowest in those areas engaged in the task. This would follow if the task causes a lowering of the amplitudes associated with a channel. Such as the attenuation of alpha rhythm. If one could predict that in general people would solve problems the same way smaller intra-person variance would also likely lead to smaller inter-person variance and thus lower the reliability coefficients for a site engaged in a task.

C4 reliability increase on task may be partially explainable by looking to Mann (1990). Mann suggests that the theta activity in the C4 area increased on task more than other areas. His statement that "C4 revealed larger increases in theta, while T5 revealed larger decreases in beta 1 in the ADHD group" (p. 98) may be interpreted to identify an area in his normal group where theta also increase in amplitude. Likely an increase in amplitude would lead to an increase in the variance both within subject and likely between subjects. The increased variance between subjects will directly affect the reliability coefficient reported here. Generally increased variance will lead to higher reliabilities.

<u>Importance of Findings</u>

The importance of reliability is that once it is established then one can begin to draw conclusions about differences between subjects after intervention or time.

The importance of identifying the characteristics of the stimuli cannot be stressed enough. Cognitive tasks that do not control for the performance of the subjects may not have a place in the future research.

Someone must spend time tightening the definition of cognitive tasks.

The drawing task is similar to a visual spatial task identified by Lubar, et al. (1985) as the best discriminator of group membership for ADD, LD (reading) and controls. Thus it is unfortunate that this task had the lowest reliability in this test - retest design. (See Mann 1990 p. 99)

<u>Suggestions for Future Research</u>

There are many areas associated with the use of QEEG and attention that need to be researched. A concurrent validity study in which an independent measure of attention is correlated with hypothesised attentional predictors in the QEEG needs to be done.

A test - retest study examining the differences in the QEEG for the interval of interest in the treatment of ADHD needs to be completed (Jansen in progress)

A test - retest design utilizing pathological groups (such as ADHD) needs to be done as it has been noted that the reliability sometimes declines in the presence of pathology.

Additional comparisons between well selected groups of normal and pathological subjects needs to be completed. (Stewart study).

Studies looking for better discriminators need to be undertaken. Perhaps tasks which can be objectively scored after the administration should be examined. Continuous performance tasks already thought to differentiate populations could be examined with QEEG to demonstrate physiological differences if they exist. An example of this type of test is the Test of Variable of Attention (TOVA) (Universal Attention Disorders, Inc. Los Alamitos, CA).

The reading task did not control for the level of interest in the stories. It is possible that the different material caused each person to react somewhat differently. Parallel content as well as difficulty level should be considered in the future if this study were to be repeated.

The drawing task produced somewhat lower reliabilities than the reading task. While the differences are not large they appear consistent across sites and bands. This may have to do with the nature of the task employed for drawing. The level of difficulty on the DTVMI (Beery, 1982) increases as one completes more of the figures. The difficulty of the Bender also increases somewhat, but arguably not as much. Thus the tasks were not strictly parallel. Changes in task difficulty have been implicated in changes in EEG by Galin, Johnstone and Herron (1978) and explored by Gevins and Schaffer (1980).

While both the DTVMI and the Bender may be scored they are not designed to look at drawing skill and the scoring may not be sensitive enough to detect small differences in effort or attention. If this study were to be repeated a different drawing task, perhaps more parallel or a completely different task such as the Koh's block design task recommended by Gevins and Schaffer might be substituted. In this task the amount of time the subject takes to complete the task is recorded and thus some measure of task difficulty can be derived.Conclusion

The findings indicate that the reliability of on task EEG, while lower than EO or EC, support the use of on task EEG recording. It appears tenable that differences between groups found during on task EEG may be due to true differences between the groups and not due purely to chance.

It is generally felt that a measure that has no reliability cannot be valid, but that reliability is not sufficient, in and of itself, to demonstrate validity. Validity is never absolute, nor can there be absolute reliability. Ultimately each researcher or clinician must decide what values for reliability and validity are good enough. This research only begins what must be an ongoing process of gathering evidence to support the reliability of on task EEG measures.

With this study as a guide it is hoped that the next study will be better designed and carried out. Hopefully new data will support the findings reported here as these findings have lent support to, and extended the findings of previous studies.

Limitations

There are some limitations to the present study. The first deals with the selection of the sample. As the students were all volunteers and they were not randomly chosen from a pool of eligible candidates the generalisability of the results is questionable. As noted in chapter two, the presence of some disorders (Dyslexia was discussed by Fein, et al., 1983) have been shown to cause lower reliabilities in some cases, thus the results may not generalise to groups of children with specific disorders.

Secondly, there were variables which, despite all efforts, remained uncontrolled in the present study. These include: 1. The amount of time spent preparing each subject for recording. 2. The actual time spent in the recording sessions for each task. 3. The level of interest in, and the level of difficulty each subject encountered when completing the tasks. 4. The amount of effort given to completing each task. 5. lack of an objective measure of task achievement standardised for all subjects.

Additional variability could have arisen due to schedule differences caused by the subject's pre-holiday school schedules. Students were involved in preparations for their school christmas program and therefore may have been engaged in different tasks prior to the recordings. The eight day retest interval also caused some of the recordings to be conducted on different days of the week, thus permitting differences in pretest activities.

Lastly, inferential statistics were not applied to determine if the differences found between the reliability of eyes closed and the other conditions is statistically significant. Without this determination one cannot state the probability that the differences are real or likely due to chance.

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APPENDIX A

CONSENT FORM

I ____________________, having read and understood the attached description of this research, give my consent to have my child participate in this research. I give my consent to have test results in the school's possession released to Troy Janzen, C. Psych.. I understand that I or my child can choose to withdraw at any time, and all information from this research project will be kept confidential. Recognizing that this research is for educational purposes, I authorize information derived from this research to be used, where appropriate, for research purposes under the direction of a University academic staff member. The confidentiality of this information will be maintained at all times.

______________________________ ________

Parents signature **Date**

______________________________ ________

Child's Signature **Date**

____

Signature of Witness

APPENDIX B
GENERAL INFORMATION AND HISTORY FORM

I. GENERAL INFORMATION

Child's Name: ____
___
last first

Birthdate: ______________________________ Sex: _
___
year month day

Name of Parent(s) with whom the child resides:

Father: ____
___
last first
Mother: ____
___
last first
Address: ____
___
Street City Province Postal
Code

Phone (home):______________ Phone (work):____________
___
Does the child live with:
Biological Parents ____________ ___________
___
mother father
Adoptive Parents _____________ ___________

___

mother

father

Step Parents ____________ ____________

___

mother

father

If this child lives in a step family, how much time does he/she spend with the other biological parent? ___
____
____
____

Please list this child's siblings and their dates of birth ________________________________
____
____

PLEASE ANSWER AS BEST YOU CAN EACH OF THE FOLLOWING QUESTIONS ABOUT THIS CHILD'S BIRTH AND INFANCY.

I. BIRTH HISTORY

#1 Country of Birth: ________________________

#2 City or Town of Birth: ____________________

#3 Hospital of Birth: ________________________

#4 Were the biological parents of this child related to each other by blood in any way?

Don't know ______ Yes ______ No ______

#5 Biological mother's obstetrical history (mark an X in all appropriate boxes).

A _____ have no knowledge of biological mother's history

B _____ had difficulty becoming pregnant with this child

C _____ have experienced miscarriage   Number _____

D _____ have experienced still birth   Number _____

#6 Biological mother's health during pregnancy with this child (Mark X in all appropriate boxes).

A _____ have no knowledge of biological mother's pregnancy

B _____ german measles during the first 3 months

C _____ high fever during the first 3 months

D _____ excessive vomiting during the first 3 months

E _____ uterine bleeding or "spotting" during first 3 months

F _____ high blood pressure

G _____ treatment for kidney problems

H _____ heart disease

I _____ chronic anemia

J _____ diabetes or suspected diabetes

K _____ surgery under general anaesthesia

L _____ thyroid disease

M _____ drugs and medication during pregnancy. Specify_____

N _____ toxemia

O _____ uterine bleeding or "spotting" during final 3 months

P _____ weight gain during pregnancy under 10 pounds

Q _____ weight gain during pregnancy over 30 pounds

R _____ induced labour

S _____ Other; Please Specify _____

#7 Age of mother at the delivery of this child.

A _____ Don't know
B _____ under 16 years
C _____ 16 - 40 years
D _____ over 40 years. Actual age ____________

#8 Length of pregnancy with this child.
A _____ Don't know
B _____ 28 weeks or less
C _____ 29 - 32 weeks
D _____ 32 - 36 weeks
E _____ over 36 weeks (child was overdue)

#9 Length of labor with this child.
A _____ Don't know
B _____ less than 8 hours
C _____ 8 - 19 hours
D _____ longer than 19 hours. Actual length ____________

#10 Child's birth weight.
A _____ Don't know
B _____ less than 5.5 pounds
C _____ 5.5 - 8 pounds
D _____ more than 8 pounds. Actual weight ____________

#11 Presentation at Birth.
A _____ Don't know
B _____ Normal
C _____ Breech
D _____ Other; Please Specify ________________________

#12 Was the child born by caesarian section?
Don't know _____
Yes _____ Anticipated _____ Emergency _____
No _____

#13 Did birth cause any injury to this child?

A _____ Don't know

B _____ yes   Specify ______________________________

___

C _____ no

#14 Is this child a twin?

A _____ Don't know

B _____ yes, 1st born

C _____ yes, 2nd born

D _____ no

#15 Family history (please mark an X for all items which have been experienced by any of this child's blood relatives).

A _____ Don't know

B _____ early blindness

C _____ squint

D _____ early deafness

E _____ diabetes before age 40

F _____ mental retardation

G _____ mental illness

H _____ heart attacks before age 40

I _____ diagnosis of Attention Deficit Disorder

J _____ diagnosis Hyperactivity

K _____ Others; Please Specify ___________________

___

#16 Child's first week of life.

A _____ Don't know circumstances of birth

B _____ baby placed in special nursery in hospital

C _____ baby stayed in hospital after mother went home

D _____ baby had breathing problems

E _____ baby given oxygen
F _____ baby jaundiced
G _____ baby given blood transfusion
H _____ baby had difficulty sucking
I _____ baby born with congenital abnormality or handicap:
Specify ____________________________________
J _____ baby suffered convulsions while in hospital
K _____ baby had no serious problems
L _____ baby given medication(s) Specify ______________

M _____ Others; Please Specify ______________________

#17 Was this child breast-fed?
A _____ Don't know
B _____ Yes How long? _____ Weeks
C _____ No

#18 Weaning
A _____ Don't know
B _____ no problem finding a suitable formula
C _____ tried several formulas
D _____ weaned to a cup

#19 Appearance of child during first few weeks after birth.
A _____ Don't know
B _____ normal appearance; healthy
C _____ pale, delicate looking
D _____ Others; Please Specify ______________________

#20 In infancy, did this child reach out to prepare himself to be picked up when a parent approached him?
A _____ Don't know

B _____ Yes

C _____ No

#21 At what age did this child first sit unsupported (sitting at least 1 minute without using his arms to support himself)?

A _____ Don't know

B _____ before 5 months

C _____ 5 - 8 months

D _____ after 8 months

#22 At what age did the child first walk unsupported (at least 10 steps)?

A _____ Don't know

B _____ before 11 months

C _____ 11 - 15 months

D _____ after 15 months

#23 At what age did the child begin to use words in a meaningful way?

A _____ Don't know

B _____ was using word by 1 years

C _____ by 1 1/2 years

D _____ by 2 years

E _____ by 2 1/2 years

F _____ after 2 1/2 years

#24 At what age did the child begin putting 2 words together?

A _____ don't know

B _____ by 1 year

C _____ by 1 1/2 years

D _____ by 2 years

E _____ by 2 1/2 years

F _____ by 3 years

G _____ after 3 years

#25 At what age did the child begin using short sentences?

A _____ Don't know
B _____ by 1 1/2 years
C _____ by 2 years
D _____ by 2 1/2 years
E _____ by 3 years
F _____ after 3 years

II. HISTORY OF ILLNESS

#26 Please check all of these which the child has experienced.

A _____ mumps
B _____ german measles
C _____ red measles
D _____ chicken pox
E _____ scarlet fever
F _____ whooping cough
G _____ chest problems Specify _______________
H _____ heart trouble Specify _______________
I _____ allergies Specify _______________
J _____ unusual reactions to vaccinations: Specify _____

-

K _____ disorders requiring surgery: Specify _________

-

L _____ meningitis or encephalitis
M _____ poliomyelitis
N _____ serious head injury with loss of consciousness
O _____ convulsions/seizures
P _____ fainting
Q _____ accidental poisoning: Specify _______________

-

R _____ failure to thrive

S _____ sleep disturbances

T _____ hospital admissions. How many by age 3 _____.

U _____ Others; Please Specify ____________________

#27 Has this child received regular immunization shots and vaccinations?

A _____ Don't know

B _____ Yes

C _____ No

#28 Does this child have any serious or chronic health problems at present?

No _____

Yes _____

If yes, please describe. (please print)____________________

____

____

____

____

#29 Is this child taking any medication on a regular basis at present?

No _____

Yes _____

If yes, please indicate the drug, dosage, and reason prescribed. (please print)____________________

____

____

____

____

____

#30 Has this child been hospitalized, or undergone surgery where general anaesthesia was given?

No _____
Yes _____ Number of hospitalizations _____
If Yes, please describe. (please print) ________________

____

____

____

____

____

III. OTHER INFORMATION

#31 Has this child had any difficulty with the following? Mark an X in front of any that apply. Mark an X in the space after the item if it is still a concern.

A _____ speech/articulation problems _____
B _____ language difficulties _____
C _____ memory problems _____
D _____ motor clumsiness _____
E _____ enuresis _____
F _____ psychological trauma _____
G _____ Others; Please Specify ________________________

#32 Is English this child's first language? Yes ____ No ___

If no, what languages are spoken at home___________

in school ___________

#33 Is this child in a language immersion program at school?

No __________ Yes__________ Language ________

#34 Would you say your child has difficulty sustaining attention?

No _____

Yes _____

#35 Does this child display hyperactive behaviors?

A _____ most of the time

B _____ some of the time

C _____ rarely

#36 Who is the child's present physician? ________________

-

IV. Emotional Functioning

#37 Please check items which best describe this child's emotional functioning at this time.

A _____ seems generally happy and has fun

B _____ cries easily

C _____ oversensitive to criticism

D _____ worries excessively

E _____ has extreme fears/frightens easily

F _____ seems frequently sad/unhappy

G _____ appears tense/nervous

H _____ handles ups and downs easily

I _____ seems to be inhibited or bottles things up

J _____ expresses anger

K _____ Others; If you wish to elaborate or add to any of the above please do so in the space provided __________

____

____

____

#38 Please check items which best describe this child's personal relationships.

A _____ gets along well with other children in a group

B _____ relates well to children one on one
C _____ has difficulty relating with other children
D _____ is often aggressive or teases others
E _____ has few friends
F _____ has many friends
G _____ can share things easily
H _____ is frequently getting into fights
I _____ bosses other children around
J _____ gets picked on by other children
K _____ seems to enjoy helping others
L _____ relates well to adults
M _____ has difficulty relating to adults
Other please describe. ____

Please write down any additional concerns/comments you may have regarding this child. ____

THANK YOU FOR TAKING THE TIME TO FILL OUT THIS QUESTIONNAIRE.

PLEASE BE ASSURED THAT ALL OF THE INFORMATION CONTAINED WITHIN THIS FORM WILL BE HELD IN THE STRICTEST CONFIDENCE.

APPENDIX C
COVERING LETTER

Dear parent(s):

This letter is to inform you of an exciting research project taking place at the University of Alberta. Recently, some work has been done by Dr. George Fitzsimmons at the University of Alberta which has discovered that Attention Deficit Disordered (ADD) and Hyperactive (ADHD) children have brainwave patterns that are slowed down when doing school-like tasks. It has also been found that these same children can then be trained to speed up their brainwaves leading to improved academic achievement.

Part of what is necessary to continue this remarkable work is to examine a group of normally achieving student's brainwaves in order to have a means of comparison to the ADD and ADHD children. Also, we would like to examine how stable the recordings are over various periods of time. For this reason each participant will be required for three different days of assessment. I require the participation of 25 normal achieving children to participate in this study. In particular I'm looking for right handed boys between the ages of 10 and 12 years. Thus, I hope that you will consider permitting your child to participate in this exciting research project.

The requirements of each participant in this study involves three things. First, each participant will be tested with an intelligence and an achievement test. Some of this testing has already been done by the school. The remaining testing will be provided at no cost and will be conducted by trained graduate students at the school. All information derived from this testing will be kept strictly confidential. Second, it will be necessary to examine each child's brainwaves while they are performing school-like tasks. Each assessment involves placing a nylon cap with sensors sewn into it over the child's head. The brain electrical information is then fed directly from the cap into a microcomputer which stores the data. In this way we can measure brainwaves with little to no discomfort or inconvenience to the child. I am hoping to conduct these assessments at the school over the next several weeks. Assessments typically last 1 1/2 to 2 hours. The first assessment will take place within the week and the second brainwave assessment will take place two weeks later. In 6-8 months I will be contacting parents to arrange a long term follow-up assessment to determine the effects of maturation on the brain wave patterns. The long term follow-up assessment will take place at the University of Alberta. All parking expenses will be reimbursed and a small reward in the form of a coupon or gift certificate will be provided to children who participate. It is important to request that your child have washed their hair and eaten a similar breakfast on the morning of the EEG assessment. Also, we will likely need to wash their hair after the assessment to remove the EEG paste.

Lastly, a history/information sheet and a short behavioral checklist will need to be completed which are intended to provide us with birth, medical, behavioral and developmental information for each child. It would be greatly appreciated if you could take the time to complete this form and return it at along with the signed consent form. The history sheet and checklist should only take a few minutes to complete and all information from these forms will be kept confidential. No specific information from these forms will be included in the written portion of this research.

To summarize, the following checklist lists the requirements of each child who participates:

- ☐ Intelligence and achievement testing to be done at the school.

- ☐ An EEG assessment to be done at the school, one this week and another two weeks later, and a final one to be done in 6-8 months.

- ☐ Please have the children wash their hair and eat the same breakfast on the morning of the EEG assessment.

- ☐ Sign and return the consent form.

- ☐ Complete and return the History form and checklist.

I thank you in advance for considering this exciting research. If these requirements are acceptable to you and your child, and your child is willing to participate, please sign the attached consent form and return it to school along with the completed Information form and Checklists. Thank you for your cooperation.

If you have any questions or concerns regarding this research, please contact me at 433-9743.

Troy Janzen M.Ed.