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Association Between Academic Performance and Electrocortical Processing of Cognitive Stimuli in College Students

Mary Menn Wolf
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Association between Academic Performance and Electro-cortical Processing of Cognitive Stimuli in College Students

Mary Menn Wolf

A thesis submitted to the faculty of Brigham Young University in partial fulfillment of the requirements for the degree of

Master of Science
In Neuroscience

Dawson W. Hedges, Chair
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ABSTRACT

Association between Academic Performance and Electro-cortical Processing of Cognitive Stimuli in College Students

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Master of Science
In Neuroscience

Because event-related potentials (ERPs) can reflect individual differences in intellectual ability, individual differences in college grade-point average (GPA) may be associated with specific individual ERP waves, such as the P300. However, P300 amplitude is higher in women than in men and varies across the menstrual cycle, factors that could confound the association between GPA and ERPs. In this regard, our objective was to determine whether differences in GPA are reflected in ERPs while standardizing for sex and menstrual phase. After participants provided informed consent, we obtained GPAs from 22 right-handed college students (11 male, age range 22 to 26 and 10 female, age range 17 to 24) at a university with high admission and retention standards. We assessed menstrual phase by measuring luteinizing hormone levels across the cycle. We then obtained ERPs for each male participant and ERPs during each phase of the menstrual cycle for each female participant in an object-recognition visual pop-out protocol using Net Station Software (Electrical Geodesics, Inc., Eugene, Oregon) and E-prime Software (Psychology Software Tools, Inc., Sharpsburg, Pennsylvania). Males had larger P300s than females. The male and female high GPA was significantly different from the low GPA male and female groups. High GPA in females and males were associated with a positive peak at approximately 689 ms that was not present in the low-GPA male group and was significantly diminished in low-GPA females. Electro-cortical processing of cognitive stimuli differs between college students with high and low GPAs.

Keywords: Electro-cortical Correlates, Event-related potential, ERP, Grade Point Average, GPA, Late Positive Component, LPC, College Student
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Introduction

GPA and Cognitive Abilities

Factors that predict grade-point average (GPA) in college have been of considerable interest. Goldman & Slaughter (1976) suggested that the GPA is biased by the differences between grading standards in different type of classes and argued that it is a composite of nonequivalent components. Others have suggested that a combination of high school-GPA and scores on the Scholastic Aptitude Test (SAT) is a good predictor of academic achievement in college (Coyle & Pillow, 2008). Rohde and Thompson (Dornhege) found that measures of general cognitive abilities were superior predictors of academic achievement. It was also found that ability is a more stable trait than academic achievement (Guo, 1998). Measures of general cognitive ability added to the prediction of academic achievement. However, none of the specific cognitive abilities accounted for additional variance in academic achievement (Rohde & Thompson, 2007). Specific personality traits strengthened the predictive power of cognitive ability and became the primary predictors of clinical performance and personal suitability (Shen & Comrey, 1997). Personality predictors can account for variance in academic performance beyond that accounted for by measures of cognitive ability (O'connor & Paumonen, 2007). Another measure of academic performance as measured by official student transcript was Error-related Negativity (Paul, Le Dantec, Bernard, Lalonde, & Rebai). A larger ERN following errors correlated with better academic performance (Hirsch & Inziicht, 2010). As with the ERN, we will show a difference utilizing event-related potentials.
Visual Evoked Potential (VEP)

The electroencephalogram (EEG) is a measurement of electrical activity of the cortical area of the brain. The visual evoked potential (VEP) (figure 1) is the neural response associated with visual events; these responses are embedded in the EEG and can be extracted by a means of simple averaging techniques (Luck, 2005). To obtain a VEP, it is helpful to record 100 ms before the stimulus to 900 ms after the stimulus.

In a VEP, there are several positive and negative waves located at different times that occur after the stimulus. Within the VEP is an Event-Related Potential (ERP), which shows different abilities related to an event requested, such as a button press. In general, the third positive wave from the stimulus is called the P300 because it occurs approximately 300 ms after the stimulus, which can be either auditory or visual (Luck, 2005; Fabiani et al, 1998; Bashore, 1991; Kirkil, 2006; Polich, 1998; and Steffensen et al, 2008).

A visual attention “pop-out” paradigm described by Steffensen et al (2008) was used in this study. There is a relevant (open diamond) which is the target, an irrelevant (diamond with cross-hairs through it), which is similar to the target but not the target, and a standard(right-facing arrow). These are set in a background of 8 right-facing arrows. The subject is to press a button whenever they see the target and do nothing at the other two scenarios. It is important that button pressing during EEG be done correctly to accurately reflect cognitive state (Polich,
This button pressing is a cognitive construct, which will elicit several waves such as the P300 around 300 ms, the late negative around 400 ms, and the late positive from 600-700 ms.

**P300**

The P300 tends to be largest at the PZ site (see fig 2), which is found at midline of the head towards the back of the crown, (Handy, 2005). Consistently, the main regions attributed to P300 include the temporal-parietal junction, medial temporal complex and the lateral prefrontal cortex (Soltani & Knight, 2000). Others find the genesis of the P300 is composed of parietal-temporal regions, parts of the medial temporal lobe, and certain thalamic nuclei (Molnar, 1994).

The P300 is one peak that is involved with recognition and categorization of the target and is also associated with the decision-making response. Further, both rare and relevant stimuli elicit the P300 component (Molnar, 1994). Found at many scalp sites, the P300 wave becomes larger when subjects cannot predict the next stimulus (Luck, 2005).

**P300 and Cognition**

Cognitive ability is highly associated with the P300. The P300 recording has considerable use in age-related cognitive dysfunction because the P300 reflects attention and memory function (Polich, 1998). Brain disorders affecting the attention allocation and immediate memory result in decreased amplitude and increased latency in the P300 (Polich, 1998). The amplitude of the P300 is proportional to the attention resources devoted to a given task and has been associated with memory performance. P300 amplitude is a measure of brain activity processing incoming information that is incorporated into the memory representation of the stimuli (Polich, 1998) and is related to the subjective probability of the stimuli (Molnar, 1994). The P300 amplitude gets larger as target probability gets smaller and becomes larger with increased effort devoted to a task (Luck, 2005). Related to age, P300 amplitude begins to
decline at age 50 (Braverman & Blum, 2003). Moreover, amplitude and latency are sensitive to individual variation in power and frequency in the electroencephalogram (EEG) (Polich, 1998). An amplitude decrease is also shown to relate to latency increase. The P300 latency is also related to speed of evaluation of a stimulus (Golgeli et al., 2004) but is independent of behavioral reaction time (Luck, 2005). Any variation that postpones stimulus categorization increases the P300 latency (Luck, 2005). Because P300 latency is an index of the processing time required before response generation, it is a sensitive temporal measure of neural activity underlying the processes of attention allocation and immediate memory (Handy, 2005).

Cognitive dysfunction and confusion are also reflected in P300 latency (Gordon, Kraiuhin, Harris, Meares, & Howson, 1986). For instance, in Sheehan’s syndrome, a condition characterized by severe deficits in growth hormone with resultant cognitive abnormalities, P300 latency is prolonged (Golgeli, et al., 2004).

P300 latency and GPA are inversely correlated in both normal and cognitively impaired college undergraduates (Polich & Martin, 1992), and P300 latency is one of the best predictors of preclinical memory impairment. Indicative of its sensitivity to detect changes in cognition, P300 latency becomes increasingly prolonged after age 40 (Braverman & Blum, 2003).

**Frontal Lobe P700 or PFC**

**P300**

A late positive component (LPC, 400-750 ms) has been shown in studies examining speakers of dialects.
of the same language with different phoneme inventories (Conrey, Potts, & Niedzielski, 2005). This LPC is known to point to episodic memory (Duzel, Yonelinas, Mangun, Heinze, & Tulving, 1997) and the processing of incongruence in presented stimuli (Buchwald, Guthrie, Schwafel, Erwin, & Lancker, 1994). The LPC is generally considered to require explicit memory for previously presented items and is sensitive to decision processes involving the sensory congruity and salience of stimuli (Conrey, et al., 2005). The frontal lobe P700 is also known as the prefrontal cortex (PFC) P300 by many ERP researchers. It relates to successful inhibition to distracters in a Go/No-go task (Chiu, Holmes, & Pizzagalli, 2008). N200 PFC (~300 ms) and later P300 PFC (~700 ms) ERP components were enhanced with successful response inhibition to emotional distracters (Chiu, et al., 2008). The Late Positive Component (LPC) is generally considered to require explicit memory for previously presented items and is sensitive to decision processes involving the sensory congruity and salience of stimuli (Conrey, et al., 2005). Go/No-go paradigms involve infrequent response inhibition in the context of frequent response generation. The target detection paradigms (oddball task) involve infrequent response generation in the context of frequent response inhibition (Braver, Barch, Gray, Molfese, & Snyder, 2001). (Luck, 2005) There were no detectable differential Anterior Cingulate Cortex (ACC) responses in either of the two tasks (Braver, et al., 2001). Functional magnetic resonance imaging (fMRI) alone confirmed the contribution of the frontal and temporo-parietal areas to the oddball response (Linden et al., 1999). The question remains whether such differences reflect compensatory processing or cognitive inefficiency or whether they assess cognitive function at all.

Considerable literature validates ERP as a powerful tool in memory research. (Walhovd et al., 2006). Many studies have detected the recognition memory task in a number of different
brain areas: hippocampus, amygdala, anterior temporal cortex, anterior cingulated cortex, lateral frontal cortex, the orbito-frontal region, and parietal cortex. Target variables such as global memory score, recognition memory scores from the ERP task, hippocampal volume, cortical volume, and ERP amplitude at Fz, Cz, and Pz (see Fig 2) correlated significantly with age (Walhovd, et al., 2006). Elderly subjects who showed frontal-maximal P300 scalp distributions had lower performance on standardized neuropsychological tests of frontal lobe function than those elderly subjects who showed posterior-maximal scalp topographies (Fabiani, Friedman, & Cheng, 1998). Findings suggest that frontally distributed ERP activity is related to poorer memory performance (Fabiani et al., 1998).

However, gifted children showed a shorter latency of P300 and faster reaction time (RT) as compared with the average standard group during a visual search task (Zhang, Shi, Luo, Zhao, & Yang, 2006). The ability to process relevant information and the ability to inhibit irrelevant information are of equal importance (Duan et al., 2009). Early ERP components reflect an attentional process being triggered by task demands and the enhanced N2 to neutral stimuli may reflect enhanced cognitive resources allocated (Chiu, et al., 2008). Another major ERP component is an enhanced wave (NoGo-P3) that is elicited within a 300–500ms time window (Bruin & Wijers, 2002). The P300 fronto-central maximum, as opposed to the centro-parietal maximum of the P300, is thought to be related to response inhibition and to index a later stage of the inhibitory process, i.e., response evaluation or the success of inhibiting a response. (Smith, Johnstone, & Barry, 2008).
**P300, N400, and Gender**

The N400 or late negative component in an ERP is linked to semantic processing under unexpected conditions. This component is found from 400 to 600 ms in the ERP.

Brain function related to cognitive ability appears different in men compared to women (Corsi-cabrera, Ramos, Guevara, Arce, & Gutierrez, 1993). For example, brain activity decreases with the level of general intelligence in males and increases with the level of general intelligence in females (Jausovec & Jausovec, 2005). P300 (Nash, 2009) and N400 amplitudes are higher in females than in males (Scott C Steffensen et al., 2008). Further, women appear to give more attentional resources toward an irrelevant stimulus than do men, which may be related to sex differences in the N400 (Scott C Steffensen, et al., 2008).

Kluck et al. (1992) suggest that there is a change in P300 amplitude across the cycle, with differences in target and non-target responses diminishing premenstrually. In contrast, the P300 latency does not appear to change with the menstrual cycle, (Kluck et al. 1992), although some findings suggest a slight increase in latency during ovulation (Tasman et al., 1999). In short, hormonal changes may affect the P300.

Hormonal changes may affect other aspects of the ERP. Nash (2009) found that P200 amplitudes are larger and occur later during menses than during the other two phases. She also found that the P300 and late negative waves vary across the menstrual cycle for the amplitude data. O’ Reilly (O’Rielly, Cunningham, Lawlor, Walsh, & Rowan, 2004) found that P300 amplitude was significantly greater during menses than the ovulatory phase. But Walpurger et al. (2004) found no significant effects on the P300 or reaction time (RT-the time from the stimulus to the pressing of the button) and no performance differences across the menstrual cycle. Differences across studies may be due to variations in the definition of menstrual phases.
and stimuli used to elicit evoked potentials. The affective value of a stimulus may be important in influencing the P300 and may change according to the menstrual cycle (Kluck et al., 1992).

**Objectives**

This study’s main objective is two-fold: 1) to demonstrate the EEG variances in persons differing in GPA, and 2) to relate these variances to differences between men and women. There have been variances found between GPA and the P300 in the latency aspect of the ERP. This study will attempt to replicate these findings and determine whether differences in P300 amplitude also occur. In addition, I will determine whether there are differences between groups in latency and amplitude of other waves. An improved understanding of the relationship between cortical function and GPA will be accomplished by comparing highly successful college students (having a 4.0 GPA) to students on academic probation (having a GPA of <2.0).

Based on findings showing EEG differences related to cognitive ability, I hypothesize that difference in student GPA will be reflected in EEG tracings. I further hypothesize that the differences in the evoked potentials between men and women will relate to cognitive ability as estimated by GPA. To test these hypotheses, I will examine highly successful college women across their menstrual cycle compared to college women on academic probation across their menstrual cycle and examine highly successful college men compared to men on academic probation. Finally, I will compare differences between female and male combined groups.

**Methods**

The BYU Institutional Review Board approved this Study.
Participants

Female and male Brigham Young University undergraduate psychology majors (ages 18 to 30 years) were recruited based on gender and grade point average (GPA). One group consisted of female and male students with a GPA of 4.0 on a four-point scale; the second group contained female and male students whose GPA was less than 2.0. We identified students meeting the GPA criteria from BYU’s Student Academic & Advisement Services (SAAS) Data-Management office and the Registrar’s office. Complying with FERPA requirements at all times, the SAAS Data-Management office provided us with a randomized list of 52 possible participants, which we kept in a locked cabinet to which only the study group had access. To keep the study blinded and follow the qualifications of FERPA, only one member of the study group (BLB) knew which students fell into which GPA groups (this information was kept in a locked cabinet). From this list, we selected potential subjects with a pre-study questionnaire (Appendix A). The first 11 qualified students (by pre-study questionnaire) in high GPA section and first 10 in the low GPA section were taken (five women and six men in the high GPA; five women and men in the low GPA category). Female participants received $80.00 after completing the four sessions required for women, and males received $40.00 after completing the two sessions required for men.

Procedures, Materials, and Design

Baseline Assessments

After providing signed informed consents, all participants completed a medical questionnaire asking about their past and present health issues, medicines taken, eyes-sight, family health; women were asked about their gynecological health (see Appendix B for a copy of
the questionnaire). This questionnaire was designed to elicit information about their general health, making sure that general health was not a factor in results.

Females were given a urine luteinizing hormone (LH) home-use test kit (Alfa Scientific Designs Inc., Poway, CA), and began testing their urine once a day for each day beginning eight days after the onset of menses, to identify exactly when ovulation occurred. Women informed the researcher when menses occurred and when a positive test for ovulation occurred. LH levels and time of menses onset were used to group female evoked-response data into the three groups (ovulation, menses, and post ovulation).

**Evoked-Potential Recording**

A visual attention “pop-out” task (Scott C Steffensen, et al., 2008) was used as a stimulus. The participants were presented with a 3 X 3 matrix with 8 right-facing arrows and an additional stimulus in random locations in the matrix. The additional stimulus was one of three possible conditions: 1) an open diamond (target or relevant), 2) a diamond with lines through it (non target or irrelevant), or 3) another right-facing arrow (control). The stimuli appeared for 50 milliseconds on the computer screen in front of the participant. There were 54 stimulus presentations for each
relevant, irrelevant, and standard conditions, for a total of 162 presentations.

After head measurement, subjects were fitted with an electrode bonnet (Hydrocel GSN 64 Electrical Geodesics, Inc., Eugene, OR) that was worn during the recording session, see figure 3. Net Station Software was used to obtain the EEG data, average the visual evoked potential (VEP) and analyze the VEP data (in the 10-20 Montage-see Figure 2). VEP’s were acquired in 1-second epochs 100ms before stimulus and 900ms after the stimulus for each visual stimulus presentation. E-prime Software (Psychology Software Tools, Inc., Sharpsburg, PA) was used for the visual attention task, which was transmitted to a computer screen (68 cm) in front of the participant and a screen in the recording room.

Men had one session with three EEG recordings (each recording consisting of 162 presentations, see first paragraph) taking approximately one hour. Males filled out medical history questionnaires (appendix B) and consent forms (appendix C) at the EEG session. Female participants met with the experimenter prior to the first recording session. During this meeting, medical history questionnaires (appendix B) and consent forms (appendix C) were obtained, and LH kits were given out. Times were set up to begin the sessions when ovulation occurs or menses occurred. A session consisted of two EEG recordings (each recording consisting of 162 presentations, see first paragraph) at menses and one recording during each of the other two phases of the menstrual cycle (menses-associated with low levels of estrogen, LH, and progesterone; ovulation-associated with an increasing level of estrogen, peak levels of LH, and low levels of progesterone; and postovulation-associated with increased levels of estrogen, low levels of LH, and increased level of progesterone).
**Preparation for Evoked-Potential Recording**

At the beginning of each session, the sensor net was placed and verbal instructions about the visual task were given, including instructions on how to respond to the stimuli. Participants were told to press a button when the relevant (open diamond) was shown and not to respond in either of the other conditions. When the task began, each participant read a standard set of instructions explaining the task and a sample visual stimulus were shown on the computer screen. Reaction times (RT) were measured from the time the stimulus was presented until the participant pressed the button. If the participant correctly detected the target, the words “correct” and the RT were displayed on the computer screen. When no target was present and participants did not press a button, the words “no response detected” were shown on the screen. An incorrect response appeared on the screen if participant pressed the button when no target was in the matrix.

**Data Processing**

The EEG around each visual stimulus was averaged to obtain the VEP for each participant. At each electrode, the visual presentations were averaged. Amplitude and latency were measured for each peak of the within-subject average VEP components for the N100, P100, N200, P200, P300, late negative or N400, and late positive or P700 waveforms, using NetStation (EGI, Eugene OR) Data Analysis Tools. Igor software (WaveMetrics, Lake Oswego, OR) and Excel (Microsoft Office) were used to present the data in graph and picture form for easier reading. Measures of Reaction Times (RT) were analyzed with ANOVA. The Males were analyzed using a MAV3RM2 (see expected means square table in appendix D1) with group (G-high/low GPA), electrode location (B), and condition (D-standard, irrelevant, relevant) as between subject factors. Females were analyzed using a MAV4RM3 (See expected means
square table in appendix D2) with group (G-high/low GPA), cycle (C-menses, ovulation, post ovulation), electrode location (B), and condition (D-standard, irrelevant, relevant) as between subject factors; this analysis being is delayed due to difficulty of the design. Male/Female analysis was made with a MAV4RM2 (see expected means square table in appendix D3) with group (G-high/low GPA), replications (C-4 for women and 3 for men), electrode location (B), and condition (D-standard, irrelevant, relevant) as between subject factors. Male participants were compared to female participants in hopes of replicating and extending previously reported gender differences. Steffensen et al (2008) and Nash (2009). Means and Standard Error of the Mean for the MANOVA’s were found and graphed for a more visual representation of differences.

**Results**

**Reaction Times (RT)**

Analyses of RT give an idea of the participants’ attention to the task. The reaction time is the time it takes for the participant to press a button once the stimulus has appeared. The first analysis compares overall males to overall females. The second analysis compares high-GPA males to low-GPA males. The third analysis compares high-GPA females to low-GPA females and takes into account reaction time across the menstrual cycle.
Combined Males and Females

Table 1: Single Factor ANOVA for RT in Males vs. Females

There were no significant differences in RT between overall males and overall females (p=0.45, F(1,72)=0.58; mean RT males = 395.97±7.31 ms vs. mean RT females = 403.01±5.97 ms, Table 1).
Males Groups

Table 2: Single Factor ANOVA for RT in Males High vs. Low

Table 2 displays the results of the ANOVA showing that there were no significant differences in RT between the High and Low GPA groups of the Males. (p=0.08, F (1, 32) =3.23; mean RT High = 407.58±10.11 ms, mean RT Low = 382.05±9.71 ms).
Females Groups

Table 3: Single Factor ANOVA for RT in Females High vs. Low

There were no significant differences in RT between the female High and Low GPA groups (p=0.69, F (1, 39) =0.16; mean RT High GPA = 405.40±9.02 ms, mean RT Low GPA = 400.62±8.01 ms, Table 3).
RT across the Menstrual Cycle

Table 4: Two factor ANOVA for RT across menstrual cycle

As shown in Table 4, RT over both high and low GPA groups varies significantly with menstrual phase (menses 1 430.8±12.4 ms, menses 2 397±13.3 ms, ovulation 399.7±7.4 ms, post ovulation 384.2±10.1 ms, p <0.0001). RT also varied between cycles within individuals (p < 0.0001).
VEP Late Components

Figure 5 VEP shows an average VEP electrode layout in the 10-20 montage with the different peaks labeled and the condition stimuli screens are on the left. The insets above the electrode show the three different conditions found in a single reading of an electrode; the three 3X3 matrices that were randomly presented at 2-4 sec intervals during the 12 min recording session (i.e., Relevant, Irrelevant, and Standard stimuli).

Figure 6: 10-20 Montage mapped on the head with color-coding representing the front, middle and back of the head. In the map of electrode positions F corresponds to frontal, C to central, T to temporal, P to parietal, and O to occipital. Pink is for the front part of the head, Brown is for the middle part of the head, Yellow is the back of the head and white is the reference.

Much of our results rely on these different parts of the head.
Grand-averaged VEP

Figure 7: VEP for Male High GPA. It is a representation of the basic VEPs found in this study. The different component peaks are labeled.

In Figure 7 the peak at the 300 to 400 ms range in back of the head is much higher in males than in females.
Figure 8: We have a relevant condition tracing of high vs. low GPA. A) and C) are Females; B) and D) are males; A) and B) are the front of the head Fz; C) and D) are the rear of the head Pz.

Figure 9: This is the relevant condition tracing of females vs. males. A) & C) are the high GPA; B) & D) are the low GPA; A) & B) are the back of the head; C) & D) are the front of the head.
Note in (figure 9) both A and B the peak at the 300-400 ms range in back of the head the males are higher than the females, this goes against several papers suggesting the opposite.

**Female High vs. Low GPA**

Figure 10, shows a comparison of females in the high GPA and low GPA range. The topomaps (circles) represent all the electrodes on the head at different times. The top set of electrodes is the front of the head and the bottom electrodes represent the back of the head. Blue-purple represent negative waves and the red-orange represent positive waves. The pre-stimulus maps show no recordable activity before the stimulus. The Pz shows the peaks in the back of the head. The N100 with activity, at about the 179 ms range, in the front of the head and back of the head, and there is approximately the same activity between the three different conditions: standard, irrelevant, and relevant. The P300 shows more activity, at about the 349 ms range, in the back of the head than in front of the head; therefore, we used an electrode (Pz) that is in the back of the head. It also shows greater activity in the relevant than the standard or irrelevant. Determining whether the high-GPA group differs in activity is difficult, but the low-
GPA group has a higher peak around the 300 ms range than the high-GPA group. The Fz topomaps represent the positive peaks in the front of the head. The LP is the peak, at about 689 ms, showing most of its activity in the front of the head. The high-GPA group has a higher peak than the low GPA group.

**Males High vs. Low GPA**

Figure 11 is a representation of the comparison of high GPA and low GPA in males. The pre-stimulus topomaps show that there is no real activity before the stimulus. In the Pz section the N100, at 179 ms, is an excellent example of equal activity; the activity in the front of the head and the back of the head are equal but opposite. It also shows that there is no difference between the three different conditions. Next is the P300, which has much larger amplitude than the females. The topomaps show that both of the relevant maps are about the same. However, the standard and irrelevant conditions of each GPA group show that the high-GPA group has a greater peak. The Fz has the LP at about the 689 ms range. The high-GPA group has much more activity than the low-GPA group at this location. Table 5
shows that there is much less interference of the standard and irrelevant in the high-GPA group, similar to the case in the female group.

**Multivariate Statistics**

![Table 5: Three Way MANOVA for Males amplitude data (** p<0.05)](image)

As shown in Table 5, there were significant differences between the two GPA conditions (High vs. Low GPA). All VEP components were significant (p <0.0001) between the two groups except for the P200 (p=0.8102), the N200 (p=0.3366), and the comparison of electrode locations. Exper (E) refers to the comparison of the three types of stimuli ( Relevant, Irrelevant, and Standard) and was significant at all eight components (N50, p = .0381; N100, p = .0063; N200, p = .0031; and P100, P200, P300, LN and LP p values were all < .0001). Group by location (G by L) interaction was significant at the LP component (p=0.0005) and at every other component (p < .0001); group by experiment (G by E) interaction was significant at seven of the eight components (N50, p = .0044; P100, p = .0140; P200, N200, P300, LN and LP all had p values of <.0001); and location by experiment (L by E) interaction was not significant at components N50, (p=0.9998); P100, (p=0.7948); N100, (p=0.9993); P200, (0.0726); and the LP, (p=0.0612): this
interaction was significant at two of the ERP components P300 and LN (p < .0001). Group by location by experiment interaction was not significant in any component.

**Males vs. Female**

**Multivariate Statistics**

**Four Way MANOVA with repeated measures**

Table 6: Four Way MANOVA Male vs. Female Amplitude data

Table 6 represents the areas that need closer attention. Gender refers to the comparison of Males vs. Females and was significant in all components. Group refers to the comparison of the two GPA conditions (High vs. Low GPA) and was significant for all components except for the P200 (p=0.9406). Loc comparison (comparison of electrodes) was significant at every component (p < .0001). Exper (E) refers to the comparison of the three types of stimuli (Relevant, Irrelevant, and Standard) and was significant at seven of the eight components (N100 p = .0063 and N200, P100, P200, P300, LN and LP p values were all < .0001) with the N50 not being significant (N50 p=0.1245). Gender by Group (X by G) interaction showed significant in seven of the eight components with P200 p=0.0267 and the other six component being <.0001, the non-significant component was P300 (p=0.695). Group by location (G by L) interaction was significant at every component (p < .0001) except the LP component (p=0.4132). Gender by experiment (X by E) interaction was significant in six of the eight components (P100 p=0.0111,
P200 p=0.0074, LP p=0.0200), the other three significant components (N50, P300, and LN) were p=<.0001. There were two non-significant components with this interaction, N100 (p=.1305) and N200 (p=0.1297). Group by experiment (G by E) interaction was significant at five of the eight components, P100 (p = .0157), N200, P300, LN and LP all had p values of <.0001; the three components that were not significant were the N50 (p=0.2733), N100 (p=0.3443), and P200 (p= 0.0857). Gender by group by experiment (X by G by E) interaction was significant in six of the eight components (N50, p=0.0011; P200, p=0.0027; N200, P300, LN, and LP all had a p=<.0001) the two components that were not significant were the P100 (p=0.1318) and N100 (p=0.5229). Gender by location by experiment (X by L by E) interaction was not significant at components N50 (p=0.958), P100 (p=1), N100 (p=0.9999), P200 (0.9994), N200 (p=0.9986) LP (p=0.9229), however, there were two significant (ERP) components P300 (p=0.0005) and LN (p=0.0023). Gender by group by location by experiment interaction was not significant in any component. The model was significant at all the components (p=<.0001).

**Statistics by GPA**

Figure 12 displays the high GPA by males and females, showing the head broken down into three sections. The N50, P100, N100, P200, and N200 in all sections of the head have no differences between the standard, irrelevant, and relevant. The front part of males (A) has significance in the Late Positive, and females (D) have significance in the P300, LN, and LP. The middle part of the head has no significance in females (E), but in the male ERP (B) does have significance in LP. The back of the head in males (C) has a definite significance in the ERP components (P300, LN and LP); the females (F) do not have a definite significance in these peaks.
Figure 12: this is a comparison to the Means & SEM of each component of the High GPA Males vs. Female. This chart plots all the conditions to see where there are statistical differences in height. The asterisk (*) represents the most obvious significance.

Figure 13 demonstrates the Low GPA by males and females, showing the head broken down into three sections. As there was a natural distribution of potentials across front, middle, and back of the head, we chose to simplify the analysis and consolidate the electrodes for statistical comparisons between regions and not just between electrodes. The front (A), middle (B), and back (C) parts of the head in males have no differences between the relevant, irrelevant, or standard in all peaks. The front part of the head in female (D) has one significant at the P300 but the other peaks have no differences between the relevant, irrelevant, or standard. This pattern is similar in the middle (E) of the head except the P300 is close to significant but doesn’t quite make it. In the back (F) of the head the P300 and LN show a definite significance, whereas the other components show no other differences.
Figure 13: this is a comparison of males vs. females in the low GPA. This is a graph of the means and SEM for each component. All three conditions were plotted to illustrate the difference caused by the distracter stimulus.
Figure 14: This is a relevant tracing of the two most important components in this study. A) the P300 is in the back of the head; B) shows the LP which is found mostly in the front of the head.

In Figure 14, only relevant condition of these waves is shown. This can be very misleading since the irrelevant and standard determines the height of the peak also. This could be done better if the percentage of the difference between the relevant and irrelevant/standard were to be used.

Figure 14 a: The males high GPA is significantly different from the low GPA males. In the females there is no significance in the relevant peaks; however, in the low females there is a significant difference between the relevant and the other two conditions as seen in figure 12f.
Figure 14 b: The high GPA shows a significant difference from the low GPA in both the males and females.

**Discussion**

This research contains several findings concerning differences in VEPs between high and low GPA groups in college students compared to students who are not as successful, when controlled for gender and menstrual phase.

**Reaction Time**

There were no significant differences in RT between males and females, between high- and low-GPA groups in males, and between high- and low-GPA groups in females. However, in females there was a significant difference in RT across menstrual cycles. This goes against some of the previous studies on menstruation where RT on cognitive tasks was not significant (e.g., Kluck et al., 1992; O’Reilly et al., 2004; Tasman et al, 1999; Walpurger et al., 2004). It is interesting that the first menses recording is much slower than the other menses, ovulation and post-ovulation RTs. Both menses recordings are made at the same session. This could be that in the menses part of the cycle there are emotional factors, which could be affecting the attention being paid to the task at the beginning of the session, but the females may settle down as the session goes on and they attend better to the task. It would be interesting to see if the RTs at the beginning of the recording are increased significantly to cause the longer RTs of the first menses recording.
Grand-average VEP’s

In the “pop-out” object recognition task, the late components of the VEP waveform are differentially altered by the behavioral task. The P300 amplitude in the back of the head was enhanced in association with the relevant stimulus. This result was expected, partly based on previous studies (Steffensen et al., 2008), and the fact that the P300 amplitude is known to be dependent on the allocation of attentional resources, as well as target salience, or the degree to which an object pops-out from a background of distracter stimuli (Coull, 1998; Katayama & Polich, 1998; Picton, 1992).

In the visual processing paradigm used in the present study, P300 amplitudes associated with the Relevant and Irrelevant stimuli were greater in males than females. In males the high GPA shows a significant value in the male P300 where as in the low GPA this significance disappears. In females the low GPA shows a significant value where as the female high GPA P300 this significance disappears. There are several studies demonstrating that ERP’s are sensitive to gender (Chu, 1987; Hoffman & Polich, 1999). The relationship between gender and the P300 has been controversial as some studies see no gender bias and others show gender differences based on various human aspects (such as emotions).

The frontal section of the head shows VEP peaks (N200, N450 and Late Positive –also called the frontal lobe P300) which are being associated with cognitive standard (Bruin & Wijers, 2002; Chiu, et al., 2008; Duan, et al., 2009; Smith, et al., 2008; Vanderhasselt & Raedt, 2009). The N2 and N450 have been measured in a modified Stroop task (Vanderhasselt & Raedt, 2009). A Go/NoGo task has produced the Frontal lobe N2 and LP (P300) activity (Bruin & Wijers, 2002; Chiu, et al., 2008; Duan, et al., 2009; Smith, et al., 2008). Cognitive control is the ability to organize incoming stimuli and inhibit a dominant response to perform a
subdominant response (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). In our task, there is a need organize the stimuli into responses to press the button for the relevant task and inhibit the button pressing for the irrelevant task. Some of these cognitive control differences are a tendency to ruminate about decisions, as in depressive subjects. However, the late positive is also thought to be due to response inhibition and may index a later stage of the inhibitory process, as seen in gifted children, such as response evaluation or the success of inhibition (Duan, et al., 2009). Smith et al (2008) study posits that the NoGo (frontal) P3 is a marker of motor inhibition. Inhibition responses are critical to managing complex environments. Dysfunctions in these processes may play an important role in the emergence and maintenance of various psychopathologies. The responses we measured in a target detection task are showing to play a role in differences between high and low GPA in college students. These responses are being measured by many ERP tasks, such as the Go/NoGo, modified Stroop task, and target detection task, frontal lobe N2 and LP (P3) (Chiu, et al., 2008).

**Results across most conditions**

The N50, P100, N100 and P200 are relatively unimportant task-related components in the VEP, as represented by the fact that the experiment by location (L by E) has no significant values with these components. This is to be expected, since they do not really have any ascribable effect attributed to button pressing.

**Females High vs. Females Low**

Basic univariate statistics show differences in the frontal section of the head’s Late Positive (Walpurger, Pietrowsky, Kirschbaum, & Wolf), P300 and Late Negative (Molnar). The high-GPA group contains elements that the low-GPA group does not. However, the back section
of the head’s P300 and Late Negative (Molnar) in the low GPA group show significance whereas the high GPA group doesn’t show significance in the components.

**Males High vs. Males Low**

Basic univariate statistics show differences in the frontal section of the head’s Late Positive (Walpurger, et al.). The high-GPA group has elements that the low-GPA group does not. Similarly, the back section of the head’s P300 and Late Negative (Molnar) show significance whereas the low GPA doesn’t show significance in these components.

**Males vs. Females**

Basic univariate statistics show differences the back section of the head’s P300 and Late Negative (Molnar) in the low GPA group females show significance whereas the high GPA group doesn’t show significance in the components. However, the male’s high GPA group show the same significance as the female’s low GPA group yet the male low GPA doesn’t show this significance as does the female high GPA. Men have higher amplitude than do women.

**Study Strengths**

This study has several strengths. First, the GPA data came from undergraduate students in only one department in one university, thus controlling for variances due to different grading standards across different departments within the university.

The use of multivariate statistics is another strength of the study in that it controlled for type-one errors due to multiple comparisons without increasing the chances of type-two errors.

In contrast to other studies that have looked at cognitive differences by means of VEPs, this study controlled for gender and menstrual phase (Duan, et al., 2009; Vanderhasselt & Raedt, 2009). Finally, this study used a real-life situation – college GPA.
Study Limitations

The biggest limitation of this study was due to the small sample size. This was due to largely to difficulty finding GPAs below 2.0. However, there were many replications of each subject, giving greater averaging across VEPs, and there was considerable statistical significance between groups. Nonetheless, it is possible that the study was underpowered to detect differences in all comparisons because of small sample size.

A major limitation of this study is that because it uses a cross-sectional design, cause and effect relationships cannot be determined.

Another limitation is that it is currently only applicable to high school and university students having GPAs as a representative for cognitive ability.

Conclusion

Based on the initial analyses conducted in this study, it is clear that the results support visual processing differences across cognitive abilities as represented by GPA differences and support or refute previous findings of gender differences using this same “pop-out” paradigm (Chu, 1987; Hoffman & Polich, 1999). However, there is support that the LN component, as well as the P300 component, varies between genders. In addition, there is evidence that other VEP components such as the frontal lobe N200 and late positive (P3) vary between cognitive control (Bruin & Wijers, 2002; Chiu, et al., 2008; Duan, et al., 2009; Smith, et al., 2008; Vanderhasselt & Raedt, 2009).

The differentiation found with VEP components in response to the pop-out task used in this study provides support for basic visual processing variation across the cognitive abilities and between genders. Future psycho-physiological studies on cognitive differences would do well to
would do well to expand the number of target VEP components and to consider assessing ERP electrode location differences in all parts of the head. Greater understanding in the frontal lobe LP would be of the utmost importance in understanding differences in cognitive ability. It should be studied more, especially working on identifying its responsibility. This is not understood or promoted very well in the literature. Imaging studies done showing reasons for activation of these areas would be very useful in identifying these areas.
References


Appendix A
Pre-Qualification Screening Interview

The purpose of this research is to study brain activity measured by brain-wave tracings, using electroencephalography or EEG, during performance of a computer-presented cognitive task using sophisticated statistics to analyze the data. Male participants will be asked to participate in one EEG session, lasting approximately 30 to 60 minutes. Female participants will be asked to participate in three EEG sessions, each lasting approximately 30 to 60 minutes.

The following questions will be used to determine if you qualify as a participant for this research.

What is your name?

What is your gender?

What is your age?

Are you color-blind?

How would you rate your current overall health? (e.g., excellent, good, fair, poor)

Do you have a personal history of physiological disorders?
Do you have a personal history of psychological disorders?

Are you currently taking any type of medication? If so, what type(s)?

**Female only:**

Have you had normal menstrual cycles (defined as lasting between 25 to 35 days) for the past three months?

Are you currently pregnant or breastfeeding?

Have you been pregnant or breastfeeding during the previous three months?

Are you currently taking oral contraceptives?

Female participants will be given a home-use urine test kit and will be asked to test their urine once a day, beginning on day 8 of their menstrual cycle, to identify when ovulation occurs. Ovulation will need to be tested across two menstrual cycles; prior to the EEG sessions and during the EEG sessions.

Would you be opposed to using a home-use urine test kit across two months?

In addition, female participants will be asked to participate in three EEG sessions during the second month of ovulation testing; once during menstruation, once at ovulation, and once
during post-ovulation/pre-menstruation phase. Menstruation history and the first month of ovulation testing will be used to approximate EEG session timeframes; however, there is a possibility that one or more EEG sessions will need to occur with short-notice (for example, if a participant’s ovulation phase occurs sooner or later than expected).

Are you available to participate during the next two months and would your schedule permit possible short-notice EEG sessions (occurring within 24 hours of reported ovulation)?

**Male and female:**

If you are selected as a potential participant for this research additional information will be given to you and you will be asked to sign a “consent to be a research subject” form.

Do you have any questions at this time?

If you qualify, would you be interested in participating in this research?

May we have your contact information?

Thank you for your time and interest in this research study.
Appendix B1

Female

Time Log and EEG

Medical Questionnaire

Name: ______________________________

General Background

How do you view your present health? Please check one

Excellent ____  Good ____  Fair ____  Poor ____

If fair or poor, please explain: ________________________________

______________________________

Are you under the care of a physician now? Yes ____  No ____

If yes, please explain: ________________________________

40
Have you consulted or been treated by clinics, physicians, healers or other practitioners within the past year for other than minor illnesses? Yes ____  No ____

If yes, please explain: ____________________________________________________________

__________________________________________

Please list all medications that you are currently taking including insulin, oral contraceptives, prescription medications, over-the-counter medications, vitamins, diet supplements, herbal supplements, etc..

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<th>Medication:</th>
<th>Taken For:</th>
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Do you have vision in both eyes? Yes ____  No ____

Do you wear glasses or contact lenses? Yes ____  No ____

Right eye:
With glasses/contact lenses ____/20  With glasses/contact lenses ____/20
Without glasses/contact lenses ____/20  Without glasses/contact lenses ____/20

Left eye:

Have you had or do you have any other problems with your eyes or vision? Yes __
No____
If yes, please explain: ____________________________________________

_________________________________________________________________

_________________________________________________________________

Personal Medical History

Have you ever been hospitalized? Yes ____ No ____

If yes, please explain: ____________________________________________

_________________________________________________________________

_________________________________________________________________

Have you ever had any surgeries in-patient or out-patient? Yes ____ No ____

If yes, please explain: ____________________________________________

_________________________________________________________________

_________________________________________________________________
Please check if you have had or currently have any of the following conditions:

- Lightheadedness/dizziness
- Loss of consciousness/fainting
- Seizures or epilepsy
- Frequent headaches
- Head injury/brain trauma
- Abnormal EEG
- Memory problems
- Numbness or tingling of arms, legs, or face
- Weakness of an arm, leg or other part of body
- Claudophobia
- Stroke
- Paralysis
- Decrease in vision
- Double vision
- Glaucoma
- Color blindness
- Cataracts
- Serious injury to eye
- Difficulty sleeping
- Psychiatric or psychological disorder

(Please explain: ____________

- Drug or alcohol abuse
- Other (Please explain: ________

)
Family Medical History

Please check if there is any history in your family of the following conditions and circle the appropriate relationship:

____ Lightheadedness/dizziness
   Child    Brother    Sister    Father    Mother    Grandfather    Grandmother

____ Loss of consciousness/fainting
   Child    Brother    Sister    Father    Mother    Grandfather    Grandmother

____ Seizures or epilepsy
   Child    Brother    Sister    Father    Mother    Grandfather    Grandmother

____ Frequent headaches
   Child    Brother    Sister    Father    Mother    Grandfather    Grandmother

____ Head injury/brain trauma
   Child    Brother    Sister    Father    Mother    Grandfather    Grandmother

____ Abnormal EEG
   Child    Brother    Sister    Father    Mother    Grandfather    Grandmother

____ Memory problems
   Child    Brother    Sister    Father    Mother    Grandfather    Grandmother

____ Stroke
   Child    Brother    Sister    Father    Mother    Grandfather    Grandmother

____ Paralysis
   Child    Brother    Sister    Father    Mother    Grandfather    Grandmother

____ Psychiatric or psychological disorder
   Child    Brother    Sister    Father    Mother    Grandfather    Grandmother
### Drug or alcohol abuse

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### Other Please explain:

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Women’s Personal Health

Age at first menstrual period: ____________

How long do your periods typically last? _______________________

How often do they occur i.e., how many days between menstrual periods?

____________________

When did your last menstrual period begin? ______________

What were the start dates of your previous three menstrual periods?

____________________

____________________

____________________

Have you ever had a change in your menstrual pattern? Yes _____ No ____

If yes, please explain: ________________________________

______________________________
Do you have any problems related to your periods? Yes ____  No ____

If yes, please explain: __________________________________________

_____________________________________________________________

Have you ever been diagnosed with a menstrual disorder? e.g., Amenorrhea, Dysmenorrhea, Menorrhagia, Metrorrhagia, Premenstrual Syndrome  Yes ____  No ____

If yes, please explain: __________________________________________

_____________________________________________________________

Have you ever taken estrogen or female hormones? Yes ____  No ____
If yes, please explain: __________________________________________

_____________________________________________________________

How many pregnancies have you had? _________
How many live births have you had? _________
How many living children do you currently have? _________
Are you currently pregnant or suspect you may be pregnant? Yes ____  No ____
Are you attempting to become pregnant?  Yes ____  No ____
Have you been pregnant within the past 6 months?  Yes ____  No ____
Are you currently breastfeeding? Yes ____  No ____

Have you breastfeed within the past 6 months? Yes ____  No ____
Appendix B2

Male

Time Log and EEG

Medical Questionnaire

Name: _______________________________________

General Background

How do you view your present health? Please check one

Excellent ____ Good ____ Fair ____ Poor ____

If fair or poor, please explain: ____________________________________________________________

__________________________________________________________

Are you under the care of a physician now? Yes ____ No ____

If yes, please explain: _______________________________________________________________
Have you consulted or been treated by clinics, physicians, healers or other practitioners within the past year for other than minor illnesses? Yes ____  No ____

If yes, please explain: ________________________________________________________________

_____________________________________________________________________________

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_____________________________________________________________________________

Please list all medications that you are currently taking including insulin, oral contraceptives, prescription medications, over-the-counter medications, vitamins, diet supplements, herbal supplements, etc..

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Do you have vision in both eyes? Yes ____ No ____

Do you wear glasses or contact lenses? Yes ____ No ____

Right eye:  
With glasses/contact lenses ____/20  
Without glasses/contact lenses ____/20

Left eye:  
With glasses/contact lenses ____/20  
Without glasses/contact lenses ____/20

Have you had or do you have any other problems with your eyes or vision? Yes __  
No ____
If yes, please explain: ________________________________

___________________________________________________________________________

___________________________________________________________________________

Personal Medical History

Have you ever been hospitalized? Yes ____ No ____

If yes, please explain: ________________________________

___________________________________________________________________________

___________________________________________________________________________

Have you ever had any surgeries in-patient or out-patient? Yes ____ No ____

If yes, please explain: ________________________________

___________________________________________________________________________

___________________________________________________________________________
Please check if you have had or currently have any of the following conditions:

- ___ Lightheadedness/dizziness
- ___ Loss of consciousness/fainting
- ___ Seizures or epilepsy
- ___ Frequent headaches
- ___ Head injury/brain trauma
- ___ Abnormal EEG
- ___ Memory problems
- ___ Numbness or tingling of arms, legs, or face
- ___ Weakness of an arm, leg or other part of body
- ___ Claustrophobia
- ___ Stroke
- ___ Paralysis
- ___ Decrease in vision
- ___ Double vision
- ___ Glaucoma
- ___ Color blindness
- ___ Cataracts
- ___ Serious injury to eye
- ___ Difficulty sleeping
- ___ Psychiatric or psychological disorder

(Please explain: ____________

- ___ Drug or alcohol abuse
- ___ Other (Please explain: _______
Family Medical History

Please check if there is any history in your family of the following conditions and circle the appropriate relationship:

- [ ] Lightheadedness/dizziness
  - Child  Brother  Sister  Father  Mother  Grandfather  Grandmother

- [ ] Loss of consciousness/fainting
  - Child  Brother  Sister  Father  Mother  Grandfather  Grandmother

- [ ] Seizures or epilepsy
  - Child  Brother  Sister  Father  Mother  Grandfather  Grandmother

- [ ] Frequent headaches
  - Child  Brother  Sister  Father  Mother  Grandfather  Grandmother

- [ ] Head injury/brain trauma
  - Child  Brother  Sister  Father  Mother  Grandfather  Grandmother

- [ ] Abnormal EEG
  - Child  Brother  Sister  Father  Mother  Grandfather  Grandmother

- [ ] Memory problems
  - Child  Brother  Sister  Father  Mother  Grandfather  Grandmother

- [ ] Stroke
  - Child  Brother  Sister  Father  Mother  Grandfather  Grandmother

- [ ] Paralysis
  - Child  Brother  Sister  Father  Mother  Grandfather  Grandmother

- [ ] Psychiatric or psychological disorder
  - Child  Brother  Sister  Father  Mother  Grandfather  Grandmother
Drug or alcohol abuse

- Child
- Brother
- Sister
- Father
- Mother
- Grandfather
- Grandmother

Other Please explain:

- Child
- Brother
- Sister
- Father
- Mother
- Grandfather
- Grandmother
Appendix C1

EEG Consent to be a Research Subject

Male Subject

Introduction

The purpose of this research is to study physiological measures, specifically brain activity measured by brain-wave tracings (using electroencephalography or EEG during performance of computer-presented cognitive tasks using sophisticated statistics to analyze the data. Graduate student, Mary M Wolf, and Dr. Dawson Hedges are the researchers doing this project. They will also be working with several undergraduate students, who will obtain the actual physiological measures. You have been asked to participate in this study because you are a healthy person whose physiological measures can be compared to physiological measures from other people and because of your interest in being a participant in a research project.

Procedures

Before the physiological measures are obtained, all subjects will complete two questionnaires. Next, you will be placed in a comfortable chair in a research room where a bonnet, or cap, containing electrodes will be placed on your head. The electrodes will measure your brain activity in several locations as you relax and then as you perform several cognitive tasks presented to you on a computer. The cognitive tasks that you will be asked to do consist of identifying a target stimulus or identifying items that you have been asked to remember. It will take up to fifteen minutes to properly place the electrode bonnet. You may experience some
scalp discomfort or even minor pain while the electrodes are fitted. The EEG session will involve a 64 channel EEG recording system and will take 30-60mins. You should not be bored during the session, as we will keep you busy asking questions and having you respond to the stimuli. Please note that the data obtained will not be used for clinical purposes but simply for this research. That is, the data obtained will not be evaluated for the purposes of personal diagnosis or treatment of neurological disease, and this research procedure does not take the place of a clinical EEG procedure.

Risks/Discomforts

There are minimal risks involved in this type of study. While the majority of people aren’t affected by the EEG procedure, and some even enjoy it, some people, for example, feel some claustrophobia from the electrode bonnet and being in the dark. You also may experience some mental fatigue during the cognitive task. You will be excluded from study participation if you have a history of seizures, claustrophobia, fainting, or brain trauma, or any physiological or psychological disorder, or if you are currently taking any long-term medication. As mentioned above, the fitting of the electrode bonnet may involve some discomfort to your scalp or even minor pain.

Benefits

There are no direct benefits to subjects for participation in this study. Indirect benefits of this study include expansion of our scientific knowledge base in physiological measures research and visual attention. You will not receive extra credit in any class for participation in this study.
Confidentiality

All information provided will remain confidential and will only be reported as group data with no identifying information. All data, including questionnaires and physiological measures will be kept in a locked storage cabinet and only those directly involved with the research will have access to them. You will be assigned a number for identification purposes; that is, your name will not be associated with any study documents. Furthermore, your standing as a student in any class or in the university at large will not be affected if you either decline to participate in the study or withdraw from the study at any time.

Compensation

You will receive $40.00 for the completion of the EEG and time logs.

Participation

Participation in this research study is voluntary. You have the right to withdraw at any time or refuse to participate entirely, without concern of penalty or question. Strict confidentiality will be maintained. No individually identifying information will ever be disclosed. There may be circumstances in which the participation of a research subject is terminated. These circumstances will be determined by the research team and may include equipment failure, scheduling problems, or your suitability for this particular project (which would include seizure, claustrophobia, brain trauma history, fainting history, history of physiological or psychological disorders, or current use of long-term medication).

Questions about the Research
If any questions or concerns arise, please feel at liberty to contact Ms. Mary M Wolf at 512-417-3644 or mmwolf02@byu.net. You may also contact Dr Dawson Hedges at 422-6357 or dawson_hedges@byu.edu.

Questions about Your Right as a Research Participant

If you have any questions regarding your rights as a participant in a research project, you may contact  

Christopher Drome, PhD, Chair of the Institutional Review Board for Human Subjects,  
133 TLRB, Brigham Young University, Provo, UT 84602; phone, 801 422-6461; e-mail, christopher_drome@byu.edu

I have read, understood, and received a copy of the above consent and desire of my own free will to participate in this study.

_________________________________  __________________________________
Name of Research Subject Print                          Signature of Research Subject

____   _______   _______
Age       Sex M/F    Date
Appendix C2

EEG Consent to be a Research Subject

Female Subject

Introduction

The purpose of this research is to study physiological measures, specifically brain activity measured by brain-wave tracings using electroencephalography or EEG during performance of computer-presented cognitive tasks using sophisticated statistics to analyze the data. Graduate student, Mary M Wolf, and Dr. Dawson Hedges are the researchers doing this project. They will also be working with several undergraduate students, who will obtain the actual physiological measures. You have been asked to participate in this study because you are a healthy person whose physiological measures can be compared to physiological measures from other people and because of your interest in being a participant in a research project.

Procedures

Before the physiological measures are obtained, all subjects will complete two questionnaires. In addition, you will be asked to document your menstrual cycle for the month of physiological recording sessions. Specifically, you will be required to document the first day of each menstrual cycle and the onset of ovulation and consult researchers when these events occur. You will be given a luteinizing hormone LH home-use urine test kit and will be required to test your urine once a day beginning on day 8 of your menstrual cycle until ovulation occurs; this
will be required for one month. During the month of participation, you will participate in a series of three physiological recording sessions in addition to documenting your menstrual cycle and testing for ovulation.

During each physiological recording session, you will be placed in a comfortable chair in a research room where a bonnet, or cap, containing electrodes will be placed on your head. The electrodes will measure your brain activity in several locations as you relax and then as you perform several cognitive tasks presented to you on a computer. The cognitive tasks that you will be asked to do consist of identifying a target stimulus or identifying items that you have been asked to remember. It will take up to fifteen minutes to properly place the electrode bonnet. You may experience some scalp discomfort or even minor pain while the electrodes are fitted. The EEG session will involve a 64 channel EEG recording system and will take 30-60 min. You should not be bored during the session, as we will keep you busy asking questions and having you respond to the stimuli. Please note that the data obtained will not be used for clinical purposes but simply for this research. That is, the data obtained will not be evaluated for the purposes of personal diagnosis or treatment of neurological disease, and this research procedure does not take the place of a clinical EEG procedure.

Risks/Discomforts

There are minimal risks involved in this type of study. While the majority of people aren’t affected by the EEG procedure, and some even enjoy it, some people, for example, feel
some claustrophobia from the electrode bonnet and being in the dark. You also may experience some mental fatigue during the cognitive task. You will be excluded from study participation if you have a history of seizures, claustrophobia, fainting, brain trauma, or any physiological or psychological disorder, if you are currently taking any long-term medication excluding oral contraceptives, or are pregnant or breastfeeding. As mentioned above, the fitting of the electrode bonnet may involve some discomfort to your scalp or even minor pain.

Benefits

There are no direct benefits to subjects for participation in this study. Indirect benefits of this study include expansion of our scientific knowledge base in physiological measures research and visual attention. You will not receive extra credit in any class for participation in this study.

Confidentiality

All information provided will remain confidential and will only be reported as group data with no identifying information. All data, including questionnaires and physiological measures will be kept in a locked storage cabinet and only those directly involved with the research will have access to them. You will be assigned a number for identification purposes; that is, your name will not be associated with any study documents. Furthermore, your standing as a student in any class or in the university at large will not be affected if you either decline to participate in the study or withdraw from the study at any time.

Compensation
You will receive $80 for completion of the three EEG’s and time logs, which will be given at the end of your research participation.

Participation

Participation in this research study is voluntary. You have the right to withdraw at any time or refuse to participate entirely, without concern of penalty or question. Strict confidentiality will be maintained. No individually identifying information will ever be disclosed. There may be circumstances in which the participation of a research subject is terminated. These circumstances will be determined by the research team and may include equipment failure, scheduling problems, or your suitability for this particular project which would include seizure, claustrophobia, brain trauma history, fainting history, history of physiological or psychological disorders, current use of long-term medication (excluding oral contraceptives, or pregnancy or nursing).

Questions about the Research

If any questions or concerns arise, please feel at liberty to contact Ms. Mary M Wolf at 512-417-3644 or mmwolf02@byu.net. You may also contact Dr Dawson Hedges at 422-6357 or dawson_hedges@byu.edu.

Questions about Your Right as a Research Participant
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Christopher Dromey, PhD, Chair of the Institutional Review Board for Human Subjects, 133 TLRB, Brigham Young University, Provo, UT 84602; phone, 801 422-6461; e-mail, christopher_dromey@byu.edu.

I have read, understood, and received a copy of the above consent and desire of my own free will to participate in this study.

_________________________________  __________________________________
Name of Research Subject       Print                      Signature of Research Subject
_______    _______                      ___________
Age        Sex M/F                      Date
### Appendix D1

**MAV3RM2**

<table>
<thead>
<tr>
<th></th>
<th>( \sigma^2 + nD\sigma^2_{p(a)b} + npD\sigma^2_{ab} + nBD\sigma^2_{p(a)} + nBD\sigma^2_d )</th>
<th>( Q_6 = \frac{A + P(A)B}{P(A) + AB} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( \sigma^2_{\varepsilon} + nD\sigma^2_{p(a)b} + nBD\sigma^2_{p(a)} )</td>
<td>( F_{p(a)} = [2] )</td>
</tr>
<tr>
<td>2</td>
<td>( \sigma^2_{\varepsilon} + nD\sigma^2_{p(a)b} + nBD\sigma^2_{p(a)} )</td>
<td>( F_{p(a)} = \frac{[2]}{[5]} )</td>
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<tr>
<td>3</td>
<td>( \sigma^2_{\varepsilon} + nD\sigma^2_{p(a)b} + npAD\sigma^2_b )</td>
<td>( F_b = \frac{[3]}{[5]} )</td>
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<td>4</td>
<td>( \sigma^2_{\varepsilon} + nD\sigma^2_{p(a)b} + npD\sigma^2_{ab} )</td>
<td>( F_{ad} = \frac{[4]}{[5]} )</td>
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<td>5</td>
<td>( \sigma^2_{\varepsilon} + nD\sigma^2_{p(a)b} )</td>
<td>( F_{p(a)b} = \frac{[5]}{[12]} )</td>
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<td>6</td>
<td>( \sigma^2_{\varepsilon} + n\lambda_{p(a)b} \sigma^2_{p(a)d} + npA\sigma^2_{bd} + nB\sigma^2_{p(a)d} + nB\sigma^2_{ad} )</td>
<td>( Q_3 = \frac{D + P(A)BD}{P(A)D + BD} )</td>
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<td>7</td>
<td>( \sigma^2_{\varepsilon} + n\lambda_{p(a)b} \sigma^2_{p(a)d} + np\lambda_{ab} \sigma^2_{bd} + nB\sigma^2_{p(a)d} + nB\sigma^2_{ad} )</td>
<td>( Q_4 = \frac{AD + P(A)BD}{P(A)D + ABD} )</td>
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<td>8</td>
<td>( \sigma^2_{\varepsilon} + n\lambda_{p(a)b} \sigma^2_{p(a)d} + nB\sigma^2_{p(a)d} )</td>
<td>( F_{p(a)d} = \frac{[8]}{[12]} )</td>
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<tr>
<td>9</td>
<td>( \sigma^2_{\varepsilon} + n\lambda_{p(a)b} \sigma^2_{p(a)d} + npA\sigma^2_{bd} )</td>
<td>( F_{bc} = \frac{[9]}{[12]} )</td>
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<td>( \sigma^2_{\varepsilon} + n\lambda_{p(a)b} \sigma^2_{p(a)d} + np\lambda_{ab} \sigma^2_{bd} )</td>
<td>( F_{abd} = \frac{[10]}{[12]} )</td>
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<td>11</td>
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## Appendix D2

### MAV4RM3

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<th>$Q_6 = \frac{aP(\alpha)E}{p(A) \cdot AB}$</th>
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<tr>
<td>P(A)B</td>
<td>$\sigma_a^2 + CD\sigma_P^2(\alpha)_b$</td>
<td>[no test]</td>
</tr>
<tr>
<td>C</td>
<td>$\sigma_a^2 + Da_P^2(\alpha)_bc + nADa_c^2 + BDA_P^2(\alpha)_c + nABD\sigma_a^2$</td>
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<td>AC</td>
<td>$\sigma_a^2 + Da_P^2(\alpha)_bc + nD_a^2(\alpha)_bc + BDA_P^2(\alpha)_c + nBD\sigma_a^2$</td>
<td>$Q_4 = \frac{ACP(\alpha)BC}{p(A)C \cdot ABC}$</td>
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<td>$\sigma_a^2 + Ca_P^2(\alpha)_bd + nACa_e^2 + BCa_P^2(\alpha)_d + nABC\sigma_a^2$</td>
<td>$Q_3 = \frac{D + P(\alpha)ED}{p(A)D \cdot BD}$</td>
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<td>AD</td>
<td>$\sigma_a^2 + Ca_P^2(\alpha)_bd + nC\sigma_a^2 + BCa_P^2(\alpha)_d + nBC\sigma_d^2$</td>
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### Appendix D3

**MAV4RM2**

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<td>$Q_1 = \frac{AGD + P(AG)BD}{P(AG) + AGBD}$</td>
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Curriculum Vitae

Mary M Wolf
225 W 4500 S
Murray, UT 84107
512-243-0354
mmwolf04@gmail.com

Education

Brigham Young University
Masters of Science-Neuroscience
GPA-3.84
Provo, UT
Sept, 2008-Apr, 2011

Colorado Technical University
Masters of Science-Management of IT
GPA-4.0
Colorado Springs CO
Feb, 2005-May, 2006

Austin Community College
Computer Sciences/Chemistry
GPA-4.0
Austin TX
Jan, 1998-Aug, 2006

University of Texas-Austin
Bachelors of Arts Major-Biology
Minor-Chem/Micro
GPA-2.45
Austin TX
Sept, 1976-May 1980

University of Texas-Austin
Bachelors of Science-Biology
Minor-Neurobiology
GPA-3.45
Austin TX
Jun, 2006-May 2007

Skills

Design Databases- Sybase, Oracle, SQL, Filemaker Pro, and Access,
Microsoft Office's-Word, Excel, Access, PowerPoint, Visio, Project and Outlook
Computer-Macintosh and PC
Programming-C, C++, Java, and Cobal
Networking skills-NT, 2000, UNIX, MAC OS X server and have a
wireless network at home,
GPS and software, photo and video software, strong web background,
mathematica, kaleidagaph,
Case tools- ERwin and microtool's Obectif
Project management tools-Microsoft Project 2003 and WBS Chart Pro, Veterinarian and medical laboratory skills-Complement Fixation Test, Particle Concentration Fluorescent Immuno Assay, Agglutination Tests, Blood screening tests, Enzyme Linked ImmunoSorbent Assay, Microbiological cultures, Vaccine viability counts, Thin Layer Chromatography, Column Chromatography, SDS-PAGE Gel Electrophoresis, Agarose Gel Electrophoresis, DNA testing and Microscopy.

**Work History**

**Master’s Student-TA**  
Brigham Young University  
Dr. Michael Brown  
Provo, UT

Working as a Teaching Assistant for Neuro Anatomy. Consists of having hours for student to ask question before each class. Also involves a review sessions where a power point presentation is given and students ask and answer questions from the material studied.

**Master’s Student**  
Brigham Young University  
Dr. Dawson Hedges Lab  
Provo, UT

Running Electroencephalograms (EEG) on participants for Thesis. Have thoroughly learned EEG testing and data analysis with Net Station software and Geodesics equipment. Have reviewed Time Management articles for information related to EEG differences. Have review women’s study articles related to EEG differences.

**Master’s Student**  
Brigham Young University  
Dr. Dixon Woodbury Lab  
Provo, UT

Providing Lab support for Dr. Woodbury’s lab. Have helped run a western blot. Do experiments on lipid bilayers comparing fusion rates. I am taking a bilayer class to gain more information about the lab. Have reviewed several articles related to vesicle fusion and types of testing.

**Owner-Upper Management**  
Austin Ceramic  
Austin Texas  
Warehouse  
Sept, 2002 to Jan, 2004

Wholesaled and retailed ceramic products of all types to customers in the Central and South Texas Areas. Promoted business with Web site utilizing major Databases for sales and accounting. Automated accounting and receivable with new database software package. Customer list also found in this new package. Improved inventory accountability 96%.

**Business Support Specialist-Database Admin**  
Texas Animal Health  
Austin Texas  
Commission  
May, 1998 to Mar, 2002
Worked as part of a project management team designing new databases. Troubleshooting, backing up, recovering, tuning, and overall maintaining databases. Implementing, analyzing data, and writing reports for databases. I, as needed, worked the help desk answering phone calls to help computer users with any problems they might have with their computers or the programs they were using.

**Assistant Director of Labs**

Texas Animal Health  
Austin, Texas  
Feb, 1992 to May, 1998

As Project Manager designed a database to hold a 2 to 3 million record system that was outdated and manual. Started quality assurance measurements and thinking in the laboratory. Performed all the research for new testing methods and bacteriology methods for the laboratory system. Did the project planning, initiation and began the execution steps for all new testing methods, for the Complement Fixation Test, and for the Bacteriology Areas. Was in charge of project execution of quality control checks on the Rapid Agglutination Test that was being performed in the back area. I regularly checked the quality checks on all the tests being performed and made corrections needed.

**Austin Lab Director**

Texas Animal Health  
Austin, Texas  
Jun, 1983 to Feb, 1992

Did project planning and research on many tests being brought into the lab to use as diagnostic test. Ran many of these test machines in research modes. Was able to improve the Complement Fixation Test capabilities from 200 tests being performed in a day with three people to 3000 tests performed in a day with one person. I gave the state an early detection system with an ELISA test, which couldn't be stabilized until we finally found the correct buffering solution. We then moved on to the PCFIA (Particle Concentration Fluorescent Immuno Assay) which really help to clean up the state of Brucellosis. I did the planning, initiating, and executing necessary in making sure that tests got approved. During this time I had to fire two employees with so lid documentation for both. And I interviewed, hired, trained, and started the lab in Lubbock in 1991. This Project (Lubbock Lab) was completely up and running within a month, running 36,000 samples by February, starting in January.

**Lab tech to Microbiologist III**

Texas Animal Health  
Austin, Texas  
Jun, 1980 to Jun, 1983

Ran various tests. Always looking to learn more and take on more responsibility. Worked in many of the testing areas of the Lab. Started to supervise and become the project manager of the Automated Complement Fixation test area. Then worked in the Elisa test area awhile. Measured out
buffers. Worked in Bacteriology occasionally. Did paperwork and worked various other areas as needed.