THE EFFECTS OF BLUE MONOCHROMATIC LIGHT ON VARIABILITY IN THE FVEP-P2

by

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THESIS CERTIFICATION

Candidate Jessica Steele defended this thesis on 23 March 2020. The members of the thesis committee were:

Professor James E. Arruda Ph.D, Committee Chair
Professor Vanessa Rainey Ph.D, Committee Member

The University of West Florida Graduate School verifies the names of the committee members and certifies that the thesis has been approved in accordance with University requirements.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

THE EFFECTS OF BLUE MONOCHROMATIC LIGHT ON VARIABILITY IN THE FVEP-P2

JESSICA STEELE

Early diagnosis of AD (Alzheimer's dementia) is imperative for treatment research to continue. The flash visual evoked potential P2 (FVEP-P2) has been shown to distinguish healthy controls from AD patients. It is a measure of cholinergic functioning within the brain which is impaired in those with AD due to the decline in acetylcholine (ACh). Previous research shows that the variability remains too high for this biomarker to be used as a clinically diagnostic tool at this time. In order to reduce variability, researchers have been manipulating the process in which the VEP waveform is produced. One promising effort is to change the light composition used to elicit the VEP. Research has been conducted to suggest that the use of blue monochromatic light may reduce variability seen in the P2. The present investigation sought to replicate these findings by comparing the traditional white to a blue strobe flash stimulus. Healthy individuals (N=24) were recruited from the University of West Florida and participated in this study to examine the psychometric properties of the white and blue light conditions. Results indicate that blue light may have the opposite effect, raising the variability in both latency and amplitude compared to that of white light. Based on these results, we suggest using an automatic algorithm for selecting the FVEP-P2 when using a white light.

Keywords: Alzheimer's dementia, Visual evoked potential, FVEP-P2, variability

INTRODUCTION

As the prevalence continues to increase, there is now more than ever a call for researchers to discover a reliable and valid measure of diagnosis for Alzheimer's dementia (AD). The prevalence of AD is forecasted to quadruple by the year 2050, which translates to 1 in 85 persons (Brookmeyer et al., 2007). The Alzheimer's Association Report projects that the number of Americans with this disease will grow from 5.5 to 13.8 million; over a 150% increase (Alzheimer's Association, 2019). This progressive neurodegenerative disease is characterized by the presence of senile Amyloid βeta (Aβ) plaques that are responsible for damaging and destroying nerve cells and triggering neurofibrillary tangles of tau protein to build inside cells within the brain. Cognitive effects include the development of severe dementia, deficits in language and information processing, and ultimately death. Despite the abundance of symptoms, any physical detection of AD is typically unnoticed until severe apoptosis, at which time the disease has progressed too far to reverse. As it stands, a definitive diagnosis of AD cannot be made without examining brain tissue via a postmortem examination (Coburn et al., 2003). Consequently, diagnoses are made for *probable* AD and are limited to exclusion criteria used to rule out other potential causes of dementia which utilizes various cognitive or neuropsychological tests. Due to the progressive nature of AD, it is recommended that those who are experiencing amnestic symptoms receive several neuropsychological tests over time to document advances in the disease (Parks et al., 1993). Further, current pharmaceutical and non-pharmaceutical treatment options cannot reverse or even halt disease progression. Rather, their administration is merely used to manage the symptoms associated with changes in mood, behavior, and memory.

The earliest and most consistent changes seen in AD is degeneration of the basal forebrain cortical cholinergic system (Gazzaniga, 2009; Iyo et al., 1997). In fact, research has shown that a decline in the cholinergic functioning could be the underlying cause of the symptoms associated with AD (Kihara & Shimohama, 2004). Cholinergic neurons, those that release acetylcholine, are affected most in the brain of someone afflicted with AD (Niikura, 2006). Acetylcholine (ACh) is a neurotransmitter that is responsible for the success of many cognitive functions, such as learning, attention, and memory. In fact, it is the degeneration of the cholinergic system that is said to result in the global dementia seen in AD patients (Gazzaniga, 2004; Koch et al., 2004). In doing so, cognition and behavior are supported throughout the day by aiding in sustained attention (Case et al., 2016; Giacobini, 2003). This is accomplished by augmenting the effects of dopamine, norepinephrine, and glutamate system function and production. Indeed, Bymaster et al. (1993) found that the use of anticholinergic drugs produced an amnesic effect in rats that mimics the symptoms of AD patients. In humans as well, research has shown that anticholinergic drugs produce amnesic effects (Parks et al., 1993). In fact, significant negative correlations between dementia severity and acetyltransferase and acetylcholinesterase activities were found by Bierer et al. (1995), demonstrating that as cholinergic function declines, dementia progresses.

One of the pharmaceutical interventions prescribed to treat AD are acetylcholinesterase inhibitors. These medications prevent acetylcholinesterase from breaking down acetylcholine in the central nervous system. This treatment is used to delay the depletion of acetylcholine in an attempt to slow the progression of the disease. Unfortunately, by the time symptoms of memory loss have been noticed, significant neuronal loss has already occurred and the use of pharmaceuticals cannot ameliorate the structural damage already existing in the brain.

Consequently, the accurate measurement of the cholinergic system's functioning might lead to early detection, improved symptom management, and the successful treatment of AD.

One such measure of cholinergic functioning has already been found to be a reliable and valid measure of cholinergic functioning in the brain (Case et al., 2016; Coburn et al., 2005; Moore et al., 1996). It is an electroencephalogram (EEG) biomarker called the flash visual-evoked potential-P2 (FVEP-P2). The FVEP-P2 is the second positive component of a VEP waveform, which is an electrical potential recorded in the central nervous system, produced after the presentation of a single strobe flash (Fix et al., 2014). Standard design for measuring the FVEP-P2 is to subject participants to several single white flashes with their eyes closed and averaging the recorded electrical potentials. The most reliable FVEP-P2 can be detected by measuring the FVEP-P2 from the richly cholinergic visual association cortex. In those without ACh abnormalities, the P2 occurs between 100 and 300 ms after the presentation of the strobe flash, although it is typically seen around 143.92 ms (Arruda, McInnis, & Steele, in press).

Conversely, AD patients typically have a selectively delayed P2 latency not seen in other forms of dementia. Implying that when the strobe flash is emitted those with AD have a delayed neurological response (Moore et al., 1996). This latency is not seen in age-matched controls (i.e., non-dementia patients) and it increases over time, mimicking dementia severity as it worsens. Unfortunately, while group differences in the FVEP-P2 latency between healthy controls and AD patients are robust, the overlap between the two latency distributions is too great to reliably place individuals in diagnostic categories, reducing the clinical utility of the FVEP-P2. The overlap seen in the group latencies is a description of the between-group variability. In other words, while the current methodology for measuring FVEP-P2 shows significant variation in the P2

latency between healthy controls and AD groups, the range and fluctuation in latency durations within each individual group remains too broad to be used for clinical diagnosis.

Because of this limitation, researchers began examining factors that may adversely impact the measurement of the FVEP-P2, including the procedure used to evoke the FVEP-P2 and the electrode sites from which the P2 might be measured. For example, Coburn et al. (2003) examined the reliability of the FVEP-P2 when measured from various recording sites and under a variety of luminance conditions, including those involving eyes opened and eyes closed conditions. The results of this investigation indicated that the most reliable electrode recording sites were occipital (i.e., Oz, O1, and O2), but only when the eyes were closed. Eye movement artifact becomes too great when eyes are left open and causes an increase in variability seen in the FVEP-P2. However, while this investigation by Coburn and colleagues (2003) was important in that it identified reliable recording sites for the FVEP-P2 and addressed between-group variability, it was not successful in reducing within-group variability by individual classification.

In an attempt to decrease distribution of latency overlap observed between those groups diagnosed with AD and healthy individuals, Fix et al. (2014) proposed the use of a double flash paradigm. In this method, the first flash was thought to act as a challenge for an already weakened cholinergic system while the FVEP-P2 was recorded from the second flash. The purpose of this novel approach was to further separate the latency distribution of healthy controls from those with mild cognitive impairment of the amnesic type (MCIa)—thought to be an early stage of AD. The results of this investigation succeeded in its purpose and further demonstrated the significant group differences between healthy controls and patients diagnosed with MCIa by presenting a double flash stimulation. The most reliable Inter Stimulus Intervals (ISIs) were between 100 and 120 ms. However, despite this increase in between-group variability, the

within-group variability of latency for the FVEP-P2 increased, continuing to prevent this procedure from being used as a clinically diagnostic tool in its current form.

To reduce the within-group variability associated with the FVEP-P2 latency, a monochromatic flash stimulus was introduced (Subramanian et al., 2012). These researchers hypothesized that the color of light used in FVEP stimulus could impact variability based on the number and distribution of cones in the retina. Colored filters, both blue and red, were tested and compared to the standard white flash. It was determined that using a monochromatic stimulation, specifically blue, reduced bother intra- and inter-individual variability in FVEP latency. The proposed explanation for the reduction in variability was that the use of blue light led to a reduction of perceptual brightness. In fact, Subramanian and colleagues reported that participants "felt more comfortable with blue light than with red and white light." This, in turn, would reduce reactionary eye movements seen in EEG data as eye-movement artifact (Subramanian et al., 2012).

The other possible explanation for the reduction in within-groups variability—one that was only touched on by Subramanian and colleagues — may be the physical composition of the light used. While white light is polychromatic, comprised of all visible wavelengths ranging from 400 to 700 nm, its use may increase within-group variability of the FVEP-P2 latency by recruiting medium- and long-wavelength cones that vary in quantity and distribution in the human retina (Roorda & Williams, 1999). Conversely, short-wavelength cones, which would be targeted by the use of blue monochromatic light, wavelengths between 400-495nm, are sparse in the human eye and are less variable in number and in distribution between people (Roorda & Williams, 1999). It is for these reasons it is anticipated that monochromatic blue light will reduce

inter- and intra- individual variability in the P2 latency in the current investigation due to the potential superiority of the short-wavelength channel and cone recruitment.

The purpose of the current study is to examine the psychometric properties of the FVEP-P2 when the standard single flash stimulus is paired with blue monochromatic light, in an attempt to replicate the findings of Subramanian and colleagues.

Hypothesis 1: Blue monochromatic light will reduce the variability associated with FVEP-P2 in terms of latency when compared to the standard white polychromatic light condition.

Hypothesis 2: Blue monochromatic light will reduce the variability associated with FVEP-P2 in terms of amplitude when compared to the standard white polychromatic light condition.

Method

Participants

Participants were recruited from the University of West Florida's Psychology Research Pool (PRP). The PRP allows undergraduate students enrolled in psychology courses to participate in research and receive extra credit in selected courses. A total of 4 Argo Points were awarded to each participant as compensation for their time. Participation was contingent on the students having no history of seizures, neurological disorders, or photosensitivity. Thirty-two students ages 18-39 (M = 24, SD = 5.6, Male = 11, Female = 21) participated in the study. Of these participants, 31 self-reported normal to corrected-normal vision. After data analysis was conducted, 7 participants were removed due to mechanical data loss. Of the 31 originally recruited participants, 24 participants ages 18-36 (M = 24, SD = 5.6, Male = 11, Female = 13) were eligible with viable data and were included in the study analyses. Informed consent was provided by all participants and approval of the University of West Florida's Institutional Review Board (IRB) was obtained prior to the commencement of the investigation (see

Appendix A). An amendment to the IRB approval was made to exclude any conditions in which a participant's eyes were opened (see Appendix B) and was subsequently approved for this investigation (see Appendix C).

Demographic Questionnaire

Demographic information was collected using a questionnaire comprised of five items in which participants reported age, gender/sex, vision proficiency, and history of neurological conditions.

Instrumentation

This study utilized the Neuroscan Curry 7 software system, a SynAmpse RT DC amplifier, and a Stim2 program on a second computer that controlled the timing of the strobe flashes (5.5 lm s/ft^2, maximum energy 1.44 J) through a Grass Model PS 33 Plus photo stimulator with a 13.7 cm diameter xenon strobe lamp. Synch pulses were sent to the Neuroscan Curry 7 system to incorporate triggers.

The relative irradiance of the polychromatic white light and a monochromatic blue light filter can be seen in Figures 1 and 2. The transmission spectra for blue light can be seen in Figure 3.

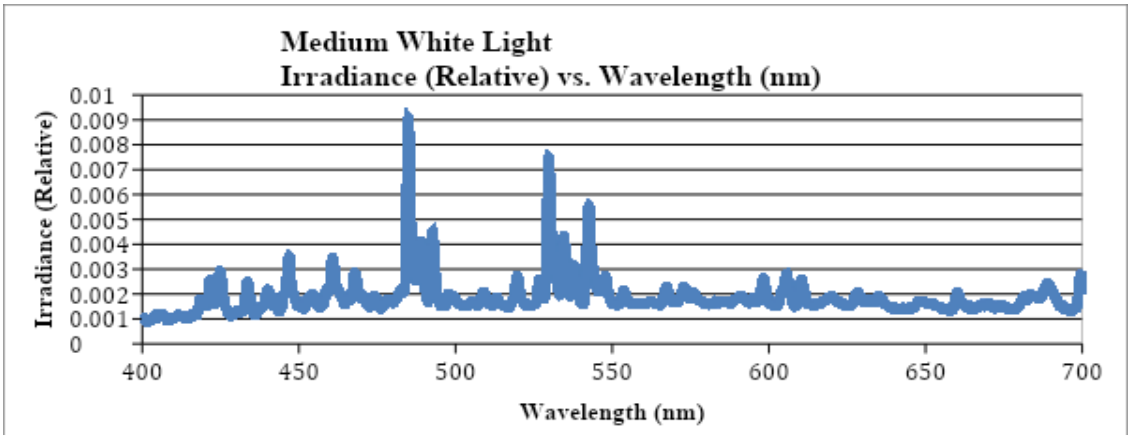

Figure 1. Relative irradiance vs. wavelength for white polychromatic light measured at medium intensity.

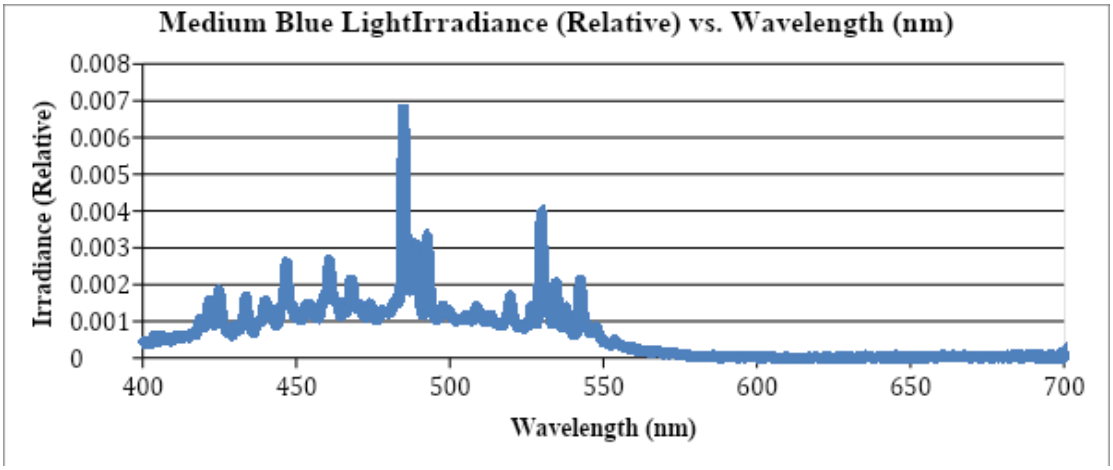

Figure 2. Relative irradiance vs. wavelength for blue monochromatic light measured at medium intensity.

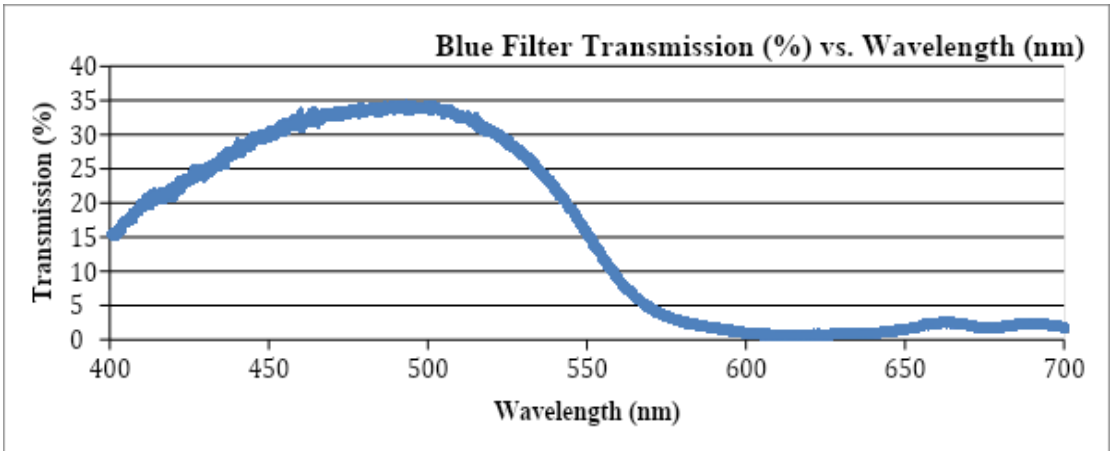

Figure 3. The percent of light transmitted through the blue monochromatic filter at specific wavelengths. The peak wavelength at which light was transmitted through the blue filter was 493 nm.

EEG Acquisition

EEG data were collected using a CompuMedics Quik-Cap-EEG 64-channel electrode cap. EEG was sampled from three electrode-recording sites O1, Oz, and O2, using a 64-channel Synamp DC amplifier at a sampling rate of 1,000 Hz, and a band pass of DC-400 Hz. The data were then band pass filtered 1–30 Hz using a zero phase shift digital filter. The recording sites,

O1, O2, and Oz were chosen based on previous research of Coburn et al. (2005) and Odom et al. (2016) that recommends these optimal sites for FVEP acquisition. All scalp electrodes were referenced to electrodes placed on the left and right mastoid (M1 and M2), and a ground electrode was placed at Fz to record ambient electrical noise. Data were epoched and then averaged around each of the flash stimulus synch pulses (i.e., −200 m/s to +500 m/s). All impedances were kept below 15k ohms for the duration of the study. Pairs of horizontal and vertical electrodes were placed superior and inferior to the eye, and one set of electrodes were placed lateral to each eye to record eye movement artifact.

Data Analysis

For selection of the P2 component of the VEP waveform, an automated peak finding algorithm was employed which determined the maximum positivity within the 100-300 ms latency window used for our single flash condition (Fix et al., 2014). Visible N1 deflections prior to the P2 peak were required to be included in data analyses. The maximum positivities were then identified, while amplitudes and latencies were subsequently recorded.

Procedure

Upon arrival, participants completed the informed consent form and were asked to complete the demographics questionnaire. Participants were then seated in a shielded room where the EEG data were collected while electrodes (i.e., O1, Oz, and O2) were placed according to the 10-20 international system of electrode placement (Coburn et al., 2005). Participants left behind all personal electronic equipment to avoid interference. Impedances were checked and the photosimulator was placed 24.5 cm from the participants' eyes (Coburn et al., 2005). After the apparatus was placed successfully on the participant, they were instructed to quietly remain seated with their eyes closed and relax as much as possible for the duration of the

study. Noise-cancelling headphones were worn by participants to mask the clicking sound produced by the strobe flash presentations; they were instructed to attend to the flash by clicking a button after each detection of the flash stimulus. Flash presentations were presented both in White and Blue conditions. During the time in which the blue filter was either added or removed, participants had a short break to avoid fatigue.

Design

The current investigation employed a within-subjects experimental design. The repeated measures factor was Color of Light (White vs. Blue). Order of conditions (k = 2) was originally counterbalanced using Latin-square due to the inclusion of single- and double-flash conditions. However, only single-flash conditions were included in the present investigation.

Participants experienced 5 blocks, consisting of 100 strobe flashes (trials), resulting in 500 strobe presentations for each condition. The FVEP-P2 was identified for each of the 5 blocks and for each of the four conditions, resulting in 5 FVEP-P2 latencies and 5 FVEP-P2 amplitudes for each condition. The FVEP-P2 was chosen using an automatic algorithm that selected the highest peak between 100 ms and 300 ms after the presentation of the stimulus.

Results

Analysis of variance (ANOVA) tests were conducted to determine if colored light influences the variability of the latency and amplitude of the FVEP-P2. The two sources of variability were intraindividual variability and interindividual variability.

Intraindividual Variability

Intraindividual variability is a measure of differences observed within a participant across the five trials or conditions. For the current investigation, intraindividual variability was defined as the standard deviation associated with the five trials and was assessed using the one-way

repeated measures ANOVA. The relevant means and standard deviations for latency and amplitude variability (i.e., standard deviations) are shown in Table 1 for blue light and Table 2 for white light. The results revealed non-significant main effects of color for latency, $F(1, 23) = 1.14$, $p = .30$, $\eta_p^2 = .05$. Similar to the variability in latency, the main effect of color was also not statistically significant for amplitude, $F(1, 23) = .22$, $p = .64$, $\eta_p^2 = .01$.

Table 1

Descriptive Statistics for Blue Light

Variable	Corrected		Uncorrected	
	Latency	Amplitude	Latency	Amplitude
Mean	169.24	7.94	168.57	8.22
SD	17.45	0.84	17.35	0.76

Note. This table shows the mean and standard deviation for blue light in both uncorrected and corrected analyses.

Table 2

Descriptive Statistics for White Light

Variable	Corrected		Uncorrected	
	Latency	Amplitude	Latency	Amplitude
Mean	163.23	11.67	165.21	11.67
SD	14.28	0.60	14.64	0.48

Note. This table shows the mean and standard deviation for white light in both uncorrected and corrected analyses.

Interindividual Variability

Interindividual variability is a measure of the difference between participants within a condition. For the current investigation, the interindividual variability was assessed using Levene's Test for Equality of Variance (i.e., homogeneity of variance). As such, within-subject data collected for each individual across the white polychromatic and blue monochromatic conditions were treated as levels of a between-subjects variable, with white and blue light being the two levels. Results of the Levene's test indicated that there were no significant differences between white and blue light for either latency, $F(1, 46) = .30$, $p = .59$ ($\eta_p^2 = .01$), or amplitude $F(1, 46) = 1.24$, $p = .27$, ($\eta_p^2 = .03$).

Post-Hoc Analysis

In order to ensure there were no confounds associated with the removal of artifacts—a standard procedure—we conducted the same analyses using uncorrected data (Table 1 and 2). Artifacts in EEG data are signals recorded that are not produced by the brain that can be internal (e.g. eye movement artifact) or external (e.g. electrical currents in the room itself where data is being collected). The results of those analyses also revealed no statistically significant difference between light conditions on the variability of the latency and amplitude of the FVEP-P2 ($p > .05$).

Discussion

The present investigation aimed to examine the psychometric properties of the FVEP-P2 when elicited by an atypical blue strobe flash. Subramanian and colleagues (2012) showed that in comparison to the standard white strobe flash, a blue monochromatic strobe flash reduced variability seen in the latency of the FVEP-P2. The current investigation sought to replicate the findings of Subramanian and colleagues by showing that inter- and intra-individual variability would be improved by the use of a monochromatic flash. Unexpectedly, the current investigation

revealed that the use of a colored flash did not reduce variability, but in fact might have had the opposite effect on both latency and amplitude. Results indicated that when the FVEP-P2 is produced by a blue flash, the variability of the P2 latency is increased, although not significantly. The treatment effects (eta-squared) associated with the type of light were .05 and .01 for latency and amplitude, respectively.

A possible explanation for the slight increase in variability seen in the blue light condition is the way the P2 component was operationally defined for this study. An automatic algorithm was employed to select the P2 component. In the automatic selection, the Neuroscan software selects the highest peak between 100 and 300 ms after the presentation of the flash. The automatic algorithm was used to reduce variability due to human error. Unfortunately, blue light produced lower amplitudes than that of white light (Mean Amplitude for Blue: 7.94, for White: 11.67), which may have adversely affected the selection of the FVEP-P2 when blue light was used. This might have occurred when the automatic algorithm identified the maximum peak. It might have missed more of the FVEP-P2 components when evoked by blue light than when evoked by white light. Thus, future research may include blue light, but should employ a semi-automatic algorithm that would be less inclined to miss lower amplitude FVEP-P2 components.

Another possible explanation may involve low statistical power. The statistical power associated with the aforementioned analyses was lower than the desired .80 level. Despite having moderate to large treatment effects pointing in a direction of blue light increasing variability of both latency and amplitude, a post hoc power analysis was conducted to determine the number of participants required to increase statistical power to the appropriate level. The power analysis revealed that 48 participants, a doubling of the current sample size, would be needed to obtain a statistically significant finding for the type of light when using a repeated measures design.

Hence, sample size and statistical power may have been more of an issue than an actual lack of effect in the population.

Limitations

A limitation of the study at hand was the sample size (N=24). Statistical power was not adequate due to the lower sample size of the investigation. Additionally, the automatic selection method employed, paired with the low amplitude associated with blue light, may have confounded results. Future research analyzing the P2 component should compare automatic and semi-automatic methods of selecting the P2 to determine if blue light produces greater variability.

Conclusion

While it was anticipated that the use of monochromatic light, specifically blue, would reduce the variability associated with the latency and amplitude of the P2 component of a VEP waveform, the opposite effect was shown here. Results of the current investigation suggest that while the standard procedure for producing the FVEP-P2 waveform with white polychromatic light remains imperfect, it may be the superior methodology when an automatic algorithm is used to detect the P2 waveform. These findings differ from those of Subramanian and colleagues, leaving room for other researchers to conduct analyses on the use of monochromatic light in production of the FVEP-P2.

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Appendices

Appendix A

Institutional Review Board Approval

University of West Florida

Research and Sponsored Programs
11000 University Parkway, Bldg. 11
Pensacola, FL 32514-5750

Ms. Jessica Steele

July 17, 2019

Dear Ms. Steele:

The Institutional Review Board (IRB) for Human Research Participants Protection has completed its review of your proposal number IRB 2019-232 titled, "Variability in the Flash Visual evoked Potential P2," as it relates to the protection of human participants used in research, and granted approval for you to proceed with your study on 07-17-2019. As a research investigator, please be aware of the following:

* You will immediately report to the IRB any injuries or other unanticipated problems involving risks to human participants.
* You acknowledge and accept your responsibility for protecting the rights and welfare of human research participants and for complying with all parts of 45 CFR Part 46, the UWF IRB Policy and Procedures, and the decisions of the IRB. You may view these documents on the Research and Sponsored Programs web page at http://research.uwf.edu. You acknowledge completion of the IRB ethical training requirements for researchers as attested in the IRB application.
* You will ensure that legally effective informed consent is obtained and documented. If written consent is required, the consent form must be signed by the participant or the participant's legally authorized representative. A copy is to be given to the person signing the form and a copy kept for your file.
* You will promptly report any proposed changes in previously approved human participant research activities to Research and Sponsored Programs. The proposed changes will not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the participants.
* **You are responsible for reporting progress of approved research to Research and Sponsored Programs at the end of the project period 06-30-2020. If the data phase of your project continues beyond the approved end date, you must receive an extension approval from the IRB.**
* If using electronic communication for your study, you will first obtain approval from the authority listed on the following web page: https://uwf.edu/offices/institutional-communications/resources/broadcast-distribution-standards/.

Good luck in your research endeavors. If you have any questions or need assistance, please contact Research and Sponsored Programs at 850-857-6203 or irb@uwf.edu.

Sincerely,

Dr. Matthew Schwartz, Interim Assistant Vice President
Research Administration

Dr. Carla Thompson, Chair, IRB for
Human Research Participant Protection

CC: James Arruda

Phone 850.474.2824 Fax 850.474.2802
Web research.uwf.edu

Appendix B

Institutional Review Board Amendment Form

IRB PROJECT AMENDMENT FORM

(Add additional pages if needed)

Title of Research Project: Variability in the Flash Visual Evoked Potential P2

Sponsoring Agency (If not funded, state N/A): N/A

Principal Investigator: Jessica Steele College/Dept.: Health/Psychology

Address: Building 41 Phone #: 2361

E-Mail: js110@students.uwf.edu Student Advisor (if applicable): jarruda@uwf.edu

Type of Amendment: (Attach human subjects training certificate if personnel are added.)

☐Add/Delete Personnel	Enter name	Enter Phone #	Enter E-mail:	Enter Role:	☐IRB Training
☐Add/Delete Personnel	Enter name	Enter Phone #	Enter E-Mail:	Enter Role:	☐IRB Training

☒Change in Procedure	☐Change in Surveys/ Questionnaires	☐Change in Recruitment/ Cooperating Site
☒Change in Consent	☐Change in Subject Population or Recruitment Methods	☐Other

Description of Amendment:

Jessica Steele and I would like to modify our original proposal (IRB 2019-232 titled, "Variability in the Flash Visual evoked Potential P2). We had originally proposed using an "eyes-open" condition for the flash stimulus, but we conducted a pilot investigation and we believe the "eyes-open" condition may be too much of a burden. The design was a 2 (eyes-open, eyes-closed) by 2 (white light, blue light) design. We would now like to dispense with the eyes-open condition and have a 2 (single flash, double flash) by 2 (white light, blue light) design. The double flash condition refers to the presentation of two flashes with 120 ms between them. It will be the second flash that we will measure the P2 latency and amplitude. All conditions would require the participants' eyes be closed. Everything else related to the proposal would remain the same.

Does the proposed amendment increase the risk to the subjects? ☐Yes ☒No
If yes, describe how.

Does the proposed amendment require changes to the consent or assent? ☒Yes ☐No
If yes, attach consent form and highlight revisions.

Does the proposed amendment affect subjects currently enrolled in the study? ☐Yes ☒No
If yes, how will subjects be notified of the changes?

Attach all revised supporting documentation (e.g., surveys, consents, ads, flyers)

Appendix C

Institutional Review Board Amendment Approval

UNIVERSITY of WEST FLORIDA

Research Administration and Engagement
11000 University Parkway
Building 11, Office 110
Pensacola, FL 32514

MEMORANDUM

September 19, 2019

TO: **Ms. Jessica Steele**
Psychology

FROM: Dr. Matthew Schwartz, Assistant Vice President Research Administration

Dr. Carla Thompson, Chair, IRB for Human Research Participant Protection

SUBJECT: IRB Modification Approval

Thank you for keeping us apprised of the progress made on your project titled "IRB 2019-232, Variability in the Flash Visual evoked Potential P2." The IRB has approved your request to modify your project based on the recently submitted application.

The IRB has approved your request based on the recently submitted modification with the following conditions: .

Continued good luck in your research!

CC: James Arruda

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