Alpha Wave Activity

In Frontal Cortical Regions

And

Dimensions of Personality

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Contents

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Abstract:

The aim of the present study was to investigate a link between alpha wave activity and personality, in a sample of thirty-five volunteers (M=20, F= 15). The participants firstly completed John & Srivastava's Big Five Inventory of personality. EEG activity was then recorded from the frontal regions while the participants underwent varying levels of stimulus. Statistical analyses demonstrated a positive correlation between alpha wave activity and agreeableness in an intermittent stimulus condition. However, no other significant correlations were observed. Therefore, it was concluded that investigation a link between alpha wave activity and agreeableness might be a useful avenue of research for future studies. Moreover the possible benefits and limitations of measuring alpha wave activity from the frontal lobes are discussed.

Introduction

General Introduction

Current research in personality psychology aspires to explore and investigate two main aspects of personality, that is human nature and individual differences (Buss, 1984). Personality psychologists are, however, faced with the difficult task of conceptualizing a person, across a variety of contexts. Many leading theorists in the field maintain that personality is defined by the most important ways in which individuals differ from one another whilst still engaging in species typical behavior across various contexts (Buss, 1984). This somewhat separates personality psychology from the rest of science. That is, as science is not usually concerned with the individual or unique, but rather the similarities within a species. Therefore many researchers, such as McCrea & John (1992), have attempted to link individual differences with human nature.

Trait vs. Biological

Early research in personality psychology, such as Allport (1937), focused primarily upon creating vast trait taxonomies in order to explain personality. The concept of a trait was used by these taxonomies in and attempt to describe and explain behavior (Winter et al 1998). Factor analysis, then, allowed researchers to pinpoint several universally common orthogonal traits (Buss & Plomin, 1975; Cattell, 1943; Eysenck, 1986; Myers & McCauley, 1985). John, Robbins & Pervin (2010) further suggest that the majority of the traits derived from these factor analyses are directly related to five cardinal traits, of extraversion, agreeableness, conscientiousness, neuroticism and openness. However in recent years, with the help of technological advances, there have been an increasing number of studies, which support a biological contribution to personality (DeYoung, Hirsh, Shane, Papademetrics, Rajeevan & Gray, 2010; Eysenck, 1967; Stemmler & Wacker, 2010; Zuckerman, 1984). Furthermore,

research suggests that genetic factors can account for almost half of the variance between traits (Riemann & Spinath 2005; Stuss & Benson, 1986; Zuckerman, 2005). Therefore there was long standing divide within the field as regards which school of thought better explained personality (John et al, 2010). For instance, Mischel & Peake (1982) seemed to suggest that trait taxonomies provided little insight into describing patterns of behavior. However, John et al (2010) maintain that the current view within the field is that although there does seem to be a biological contribution to personality, traits are still an important measure of individual differences and a sound predictor of observable behavior.

Eysenck's Psychoticism and Neuroticism Hypotheses

Over his life, personality psychologist Hans Jürgen Eysenck developed, through factor analyses, the PEN model of personality (Eysenck, 1967, 1986, 1994). The traits that this model proposed and examined were extraversion, neuroticism and psychoticism. However due to the growing number of studies, which suggested a biological contribution to personality, Eysenck was forced to try and explain a biological basis for his traits. Eysenck (1967) suggested a number of ways in which his three cardinal traits stemmed from biological processes. In the broad form, Eysenck proposed that all nervous systems are not the same. Therefore differences in structure and level of functioning lead to individual differences in the emergence of traits (Cooper, 2010). More specifically, Eysenck hypothesized that neuroticism was an emotional trait. Therefore this lead Eysenck to reason that levels of neuroticism are dependent on differences in brain structure and thus neuroticism is expressed in relation to sensitivity to external stimulus (Cooper, 2010). Eysenck further found males to be typically higher in psychoticism than females. These findings then lead Eysenck (1967) to hypothesize a possible correlation between male hormones and psychoticism. However Eysenck is often criticized due to a lack of empirical evidence to support his claims about the biological basis for psychoticism and neuroticism. (Cooper, 2010; Gray, 1981; Gale 1983; Hagemann & Naumann, 2009)

Eysenck Extraversion Hypothesis

Although Eysenck lacked much empirical support for his psychoticism and neuroticism hypotheses, evidence for his extraversion hypothesis may be better supported. Briefly, Eysenck (1994) posed a theory that individual difference in the emergence of extraversion was due to differences in the ascending reticular activation system (ARAS). Eysenck (1994) hypothesized that individuals who are highly extraverted have lower levels of cortical arousal, higher amplitude and lower frequency of alpha wave activity. Then in contrast, Eysenck suggested that people who had lower levels of extraversion, thus were more introverted, had a higher levels of cortical arousal which in turn lead to lower amplitude and higher frequency of alpha wave activity (Eysenck, 1994). The rationale behind this hypothesis was that a lower level of cortical arousal is associated with being an uncomfortable condition. Therefore people who are highly extraverted seek out typical extraverted behaviors and activities in an attempt to increase their arousal (Eysenck, 1994). Eysenck (1994) further proposed that EEG alpha wave reading should serve as the standard measure of cortical arousal. Therefore in the present study EEG will be used as the standard measure of alpha wave activity and then in turn measuring cortical arousal.

Research from the field

This cortical arousal hypothesis put forward by Eysenck is the cause of much debate in the area of personality psychology. Various studies have been shown to support Eysenck's claim of high levels of extraversion being associated with low cortical arousal and high alpha wave activity (Savage, 1964; Wall, Schuckit Mungus & Ehlers 1990; Zuckerman 1991). However there have been conflicting research findings which seem to associate low levels of extraversion with high levels of alpha wave activity (Young, Lader & Fenton, 1971) Therefore these findings would seem to indicate that introverts have low levels of cortical arousal.

Other research then indicates that there is no correlation whatsoever between extraversion and alpha wave activity (Fenton & Scott, 1967; Gale, Coles, Kleine & Penfold, 1971). Furthermore, although Gale et al (1971) found no significant difference between introverts and extraverts on EEG, they did find that the high neurotic group did have a greater level of EEG activity, across several bands. However in a similar study, Savage (1964) found there to be no significant difference between neurotic groups but however did find a significant difference between introversion and extraversion.

Gales Research

In an attempt to try and explain that variation in results, Gale (1983) conducted meta-analyses of all known studies, which investigated alpha wave activity and the extraversion-introversion hypothesis. This meta-analysis examined thirty studies, which related alpha wave activity to extraversion. The results of these meta-analyses, according to Gale (1983), flagged a number of inconsistencies and errors in previous research. For instance, Gale (1983) suggests that many of the studies misunderstood Eysenck's theory, misinterpreted the data and personality was measured in an unsystematic fashion. Moreover, Gale (1983) found that statistical analysis was weak in these studies and there were significant issues with both sampling and scoring.

Gale (1973) further suggested that the contradictory research findings maybe due conflicting experimental designs and techniques. After reviewing literature in the area, Gale Coles & Blaydon (1967), devised a new condition for measuring EEG and extraversion. Gale et al (1967) reasoned that either high or low arousing tasks were unsuitable to examine extraversion and EEG. Therefore a moderately arousing level of stimulus should be applied when studying extraversion (Gale et al, 1967). Gale and collogues maintained that this moderately arousing condition should be characterized by instructions from the experimenter, to the participant, to open and close their eyes. Gale et al (1967) found that in this condition,

there was a significant difference between the introverted and extraverted groups, in terms of EEG output. Therefore, following this study Gale (1973) maintains that a condition which allows a moderate level of interaction between the experimenter and participant to be the most accurate condition to measure cortical arousal and thus should be applied to all future studies. Gale (1973) further reasoned that arousal levels would, presumably, not be affected by the experimental conditions however some interaction between the experimenter and the participant was needed. Thus Gale suggested intermediate arousing conditions to be the only appropriate level of stimulus when measuring cortical arousal and personality (Gale 1973, 1981).

Although Gale claims that a moderately arousing level of stimulus is the only appropriate for measuring EEG and personality there doesn't seem to be evidence support this claim in relation to the personality traits other than extraversion (Gale 1973, 1983). Gales (1973) explanation for not using high or low levels of arousal was based on a meta-analysis of studies, which primarily focused on extraversion and the PEN model. Gales (1981) rationale for not using high or low levels of stimulus may be sound in the case of measuring extraversion; however there seems to be little reason to adopt that stance for each of the other traits. This reasoning has been applied to the vast majority of research on alpha wave activity and personality since Gales initial hypothesis.

Frontal Lobes and Alpha Wave Activity

Another reason for the conflicting findings regarding cortical arousal and extraversion may be due to the site where the alpha wave activity is being measured (Tran, Craig, McIsaac, 2001). Much research has demonstrated an association between the frontal subcortical circuits and personality (Cummings, 1993; Ekman, Davidson & Friesen, 1990; Stuss & Benson, 1986; Sundram et al, 2012). For instance, Meyers, Berman, Scheibel & Hayman (1992) examined acquired antisocial personality in a patient who underwent sugary for a pituitary tumor. After

surgery, the patient began to exhibit behavioral changes, which were apparent to both family and health care professionals. However formal neuropsychological tested showed no significant cognitive deficits. An MRI scan did however reveal damage to a region of the left orbitofrontal cortex. The researchers were then able to hypothesize, with a degree of confidence, that that damage may have lead to personality and behavioral changes (Meyers et al, 1992).

There it would seem that the frontal regions would be the prime location to record alpha waves from. However there may be issues with measuring alpha wave activity from this location. For instance, Niedermeyer (1987) suggests that alpha waves should be primarily measured from posterior regions of the brain and as apposed to the frontal regions. However despite this, Tran et al (2001) still maintain that measurement of alpha waves in the frontal region of the brain could be a useful in describing a link between personality and brain wave activity.

Stoop Test and the Frontal Lobes

In order obtain a high level of stimulus in the frontal lobes; a Stroop test will be administered to each participant in the high level of stimulus condition. Research suggests that Stroop performance is directly linked with the frontal lobes (Alvarez, Emory, 2006; Demakis, 2004). Moreover research, such as Stuss, Floden, Alexander, Levine & Katz (2001), has found Stoop interference as a useful measure of frontal lobe function.

Further Research

A key study in this area includes Tran, Craig & McIsaacs (2001) study on extraversion-introversion and alpha wave activity in the frontal lobes. This research used Cattell's 16-factor model of personality and followed Gales hypothesis regarding moderately arousing stimulus condition. The results from this research indicated a relationship between introversion-

extraversion in the frontal EEG alpha wave activity. The results showed that extraverts were three times more likely to have larger amplitude activity in the frontal regions, thus in keeping with Eysenck's original extraversion hypothesis. Moreover no significant associations were found in the posterior regions of the brain thus leading the researchers to conclude that extraversion is linked to the frontal lobes and not the previously highly studied posterior lobes. (Tran, Craig & McIsaac, 2001).

However, another recent key study in the area has conflicting results with that of Tran et al (2001). Hagemann & Naumann (2009) found there to be only a weak relationship between extraversion and alpha wave activity across all locations of the 10/20 international system. Moreover Hagemann & Neumann's study also investigated the role of which external factors play in altering alpha wave activity. Eysenck (1994) posed that a possible reason for conflicting results in the area was due to variance caused by external factors. Eysenck hypothesized that any number of external factors could influence the EEG readings and further claimed any correlations that were seen, were unlikely to be high (Eysenck, 1994, Hagemann & Naumann, 2009). Hagemann & Naumann (2009) remarked that Eysenck's external factor hypothesis was not supported by literature and should be investigated. Research findings suggested that that external factors do not have a substantial impact on EEG readings once the study follows a clear standardized recording process. Interestingly this research also indicated that there was no significant relationship between extraversion and alpha wave activity (Hagemann & Naumann, 2009). Due to Eysenck's external factors hypothesis not being supported by evidence the present study shall adopt the stance that external factors have minimal effect, if any, on EEG alpha wave activity. Therefore this shall not be controlled for in the present study. However the contradictory findings from the above study with regard to extraversion shall be investigated in the further.

Five Factor Model as an assessment of personality

This Big Five Inventory proves as a useful alternative to the PEN model and Cattell's 16-Factor model therefore the present study intendeds to employ it as the assessment measure of personality. The Big Five Inventory includes five dimensions of personality, which are extraversion, neuroticism, agreeableness, openness and conscientiousness. However, the vast majority of research on EEG and personality use either the PEN model of personality (e.g. Hagemann & Naumann, 2009, Gale et al 1967 etc.) or Cattell's 16-factor model (e.g. Tran et al, 2001) as the assessment tool for personality and somewhat neglect The Big Five Inventory. However this trend does not reflect current practice within psychology (John et al, 2010). In fact according to John et al (2010), there was a total of two hundred and fifty publications using either the 16-factor model or the PEN model on PsycINFO database between 2005 and 2009. This is in comparison with over one thousand six hundred publications using a variant of the Five Factor Model (John et al, 2010, p 116). Therefore it would seem the Big Five Inventory would act as a useful measure of personality in the present study.

Although the vast majority of EEG and personality research somewhat neglects the Five Factor Model, Tran, Ashley & Nirupama (2006) have used the a Five Factor Model to assess brain wave activity in the resting state and personality. Tran et al (2006) specifically looked at contributions of the traits to delta and theta activity. Results indicated that traits have a small but significant contribution to brain wave activity, approximately 7% for Delta and 5% for Theta (Tran et al, 2006).

Rationale for the Present Study

Firstly, the on the whole aforementioned studies demonstrate that there clearly isn't consensus among personality psychologists and theorists as to the underlying biological mechanisms behind traits and observable behavior. Moreover, following Eysenck's (1967) original trait hypothesis, much research went into examining a correlation between extraversion and alpha wave activity. However other traits have not been as extensively

researched in relation to a possible relationship with alpha wave activity. Therefore this broadly provides the rationale behind the present study.

Gales hypothesis then adds further rationale to the proposed study. Gales reasoning for using an intermittent level of stimulus is questionable. For instance, Gale (1983) prosed a theory that an intermittent level of stimulus was the only appropriate method of assessment of alpha wave activity and personality after he used this method in his own research. Furthermore, Gale fails to explain why an intermittent level of stimulus is suitable for measuring alpha wave activity other traits. Therefore the present study aims to assess Gales hypotheses by examining alpha wave activity under a low, intermittent and heightened level of stimulus.

On top of that, there seems to be a lack of research investigating alpha wave activity in the frontal lobes despite a substantial amount of evidence indicating a correlation between frontal cortical regions and personality. Although, due to the possible difficulties associated with of obtaining alpha wave readings from the frontal regions, this lack of research may be somewhat justified. Nevertheless, the present study aims to investigate personality and alpha wave activity in the frontal lobes in an attempt to conclude whether it would be a useful avenue for research for future studies.

Furthermore, previous research within the area has primarily used either the 16-Factor Model or the PEN model as the assessment tool for measuring personality. This is not however in keeping with current trends within personality psychology. Therefore the present study will use the Big Five Inventory, as the assessment tool of personality. Moreover, the Big Five Inventory has four traits that are not explicitly named in the PEN model. Therefore it stand to reason that previous research might have overlooked relationships between the other dimensions and alpha wave activity.

The present study also offers another benefit. Eysenck originally devised his alpha wave/extraversion hypothesis in the nineteen sixties. However there have been numerous technological advances since Eysenck proposed his theory. Therefore perhaps EEG techniques

and alpha wave activity may not still be the most fruitful avenue for personality exploration. Thus another benefit of the proposed study could be clarification of whether or not alpha wave activity is actually a useful indicator of personality, and whether or not research should geared toward more advanced neuroimaging and genetic micro arraying techniques.

Present Study

Briefly, thirty-five volunteers will take part in the experiment as well as fill out the Five Factor model questionnaire. The experiment is a within participants design and therefore every participant will take part in each condition. The conditions will consist of a low, intermittent and high condition. For the low condition participants will have their alpha activity recorded in an eyes closed, relaxed state. The intermittent condition then involves the participant opening and closing their eyes following a command. The high stimulus involves the participant taking a Stoop Test.

Hypothesis

Overall it is hypothesized that there will be a significant relationship between personality and alpha wave activity. More specifically, it is hypothesized that there will be a significant relationship between level of extraversion and alpha wave activity in the intermittent level of stimulus condition. It is also hypothesized that there may a significant relationship between each trait in each stimulus condition. It is also hypothesized that the Stoop test will provide a heightened level of stimulus, in the frontal lobes, for the high stimulus condition.

Method

Participants

A total of thirty-five volunteers, (20 male, 15 female) were recruited basis of opportunity sampling. All participants were over eighteen years of age, as research suggests that alpha wave activity increases between adolescence and adulthood (Kolev, Yordanova, Basar–Eroglu, Basar, 2002). Age was then measured through several age ranges, with the twenty-three participants falling in the age 18-22. These participants were recruited primarily through use of Facebook and email advertising. Thirty-three of the participants were undergraduate students studying at various universities throughout Dublin. As regards dexterity, thirty-two of the participants described themselves as being right hand whereas three participants reported being left-handed. All participants successfully completed the personality questionnaire and artifacts were controlled through the EEG analyses therefore there where no participants excluded from analyses.

Design

The design of the experiment in the present study mixed design, as there were quasi-experimental and correlational elements to the study. The predictor variable was alpha wave activity and scores on dimensions of personality were treated as the criterion variable.

Materials

In the present study, the Big Five Inventory (John & Srivastava, 1999) used as an assessment of personality. This version of the Big Five Trait Taxonomy had forty-four items. The dimensions of personality measured by this inventory include extraversion, openness, neuroticism, agreeableness and conscientiousness. The participants were asked to respond to the items using a five-point liker scale ranging from Disagree Strongly at one to Agree Strongly at five. The participants were instructed to score each statement depending on the

degree to which they either agreed or disagreed with the statement. The Big Five Inventory has a mean internal consistency of .83 (John et al, 2010). Moreover, The mean uncorrected and corrected convergent validity correlations scores are .80 and .95 respectively. Furthermore the Five Factor Model has also demonstrated reliability cross-culturally (Pervin & Cervone, 2010).

Along with the Big Five Inventory, a short demographics questionnaire was also used. This demographics questionnaire contained four items that indicated gender, age, education level and dominant hand of each participant. The age variable was measured in terms of age range.

Other materials included a consent form and debriefing form. A computer along with biofeedback machine and cables, earplugs, electrode cap, electro gel and blunted syringe were also used in order to obtain an EEG reading. A toothbrush and tissue were used to clean the apparatus after use and baby wipes were provided for the participant.

Apparatus

The assessment itself took place in DBS Balfe Street psychometric Lab. Before the experiment commenced each participant was given a Boots Baby Soft Wipes: Fragrance Free. The apparatus used to record and analyze the EEG activity was a Compaq microtower Desktop 2.66ghz computer running Adinstruments Labchart v7 and Labchart Reader V7.3.4. The biofeedback unit itself was an Adinstruments Powerlab 26/T unit. The electro-cap used was the Adinstruments MLAEC1 EEG medium cap with ear electrode. Adinstruments MLAE11 Electro-Gel (32 oz) was also used in an attempt to obtain stronger EEG readings. This electro-gel was applied to the frontal electrodes through the use of Adinstruments MLAE6 syringe and blunt needle. Pairs of Boots Pharmaceutical Muffle Wax Earplugs were also issued to each participant and were discarded after use. A Colgate Zigzag plus medium toothbrush was also used to clean electrodes between each participant. The stroop test then was administered on an Apple iPad 2 16gb running the application “Stroop Effect”. Analyses of data were then conducted via SPSS V 20 on a MacBook 2.4 GHz laptop running Windows 7.

General Procedure

Prior to assessment all participants were brought into DBS Balfe Street Psychometric Lab and briefed about the experiment. This brief contained information about the rationale for the study, what was involved in taking part, duration of the experiment and rights of the participant.

Each participant was informed that the rationale for the study was to investigate a proposed a link between brain wave activity and personality. The briefing then went on to give a detailed explanation of what was required by the participant and the possible risks associated participation. An approximate completion time, of thirty minutes, was then expressed to the participant. Anonymity of results was assured to each participant and their right to withdraw or discontinue participation at any point was explained. Finally, a question and answer period was allowed at the end of the briefing in an attempt to further ensure informed consent.

After the briefing had concluded, each participant signed a consent form stating his or her willingness to participate in the study. Once the participant had signed the consent form they were then presented with two questionnaires. The first of the questionnaires was a short demographics questionnaire. The next questionnaire was the Big Five Trait Taxonomy. (add reference)

Upon completion of both questionnaires the participant was then prepared for the EEG acquisition. The first step in the preparation was the removal of any dead skin or make up from the forehead. In order to do this the participant, through the use of fragrance-free protective wipes, cleaned their forehead. An electrode cap was then fitted over the participants' head and a clip on electrode was applied to their right earlobe. In an attempt to ensure that data was not confounded by external visual stimuli, the participants were instructed to face a closed shutter for the duration of the experiment. In a further attempt to control for external auditory stimuli, each participant was asked to wear sound muffling earplugs for the duration of the study.

After preparation of the EEG was compete, the EEG was then recorded under three levels of stimulus. These levels included a low level of stimulus, a moderate level of stimulus and a high level of stimulus. Alpha wave activity was measured over the three levels each for a period of five minutes; with a one-minute break in-between each condition. Throughout each condition the participant was asked to move as little as possible in order to obtain accurate EEG readings. The experimenter remained in the room for the duration of the experiment.

In the first condition that was examined was the low level of stimulus condition. In this condition the participant was asked to sit into a desk, close their eyes and try and relax for five minutes. Upon completion of the condition, participants were allowed to open their eyes and move around before the next condition started.

The next condition was the moderate level of stimulus condition. In this condition the participant was instructed to either open (EO) or close (EC) their eyes every thirty seconds. The order of which went as follows (EO, EC, EO, EC, EO, EC, EO, EC, EO, EC). This condition was viewed as moderately arousing as there is an interaction between the participant and experimenter, however this interaction does not provide a high level of arousal. The participant was also informed that during the EO condition they were able to blink as required.

For the high level of stimulus condition participants were asked to do a Stoop Test on an iPad. Before the Stroop Test started, the participant was given a demonstration and explanation of how the stoop test worked. The participant was then asked to have a sample run of the stroop test in order to ensure understanding of the test. The Stroop Test was on a loop of thirty-second rounds and each participant completed ten rounds. The iPad was placed on the desk and the participant was asked to move as little as possible only moving their hands to pick response.

The participant was then provided with cleaning facilities and debriefed about the experiment. In each case the participant were asked if they had any questions regarding the experiment. After this, a debriefing information sheet was offered to the participant. The

debriefing sheet consisted of helpline numbers, a key reference regarding the rationale for the study and contact details of the experimenter. The participants were then thanked for their participation in the study and offered further contact details regarding the results of the study.

EEG Registration

EEG readings were recorded from 2 frontal sites of the international 10/10 system using AG/AgCI electrodes. Both sites were referenced to the right earlobe. Data signals were acquired at a sampling rate of 200Hz and with a gain set of 10:1.

After EEG acquisition, all EEG recordings were assessed separately for each condition. The first part of the assessment was to smoothing the data based on averaging three samples. This was done in an attempt to control for artifacts such as noise.

All EEG data was then subject to Fast Fourier Transform (FFT) analysis at a size of 16k in an attempt to ensure waveform resolution was not lost (Tran et al, 2001). All data was then extracted through a Hamming window. Power values were then averaged across the alpha band (8-13 Hz) and the data was further averaged on power density and converted from microvolts to Hertz (Hagemann & Naumann, 2009). This value then gave an indication of Alpha wave activity (Tran et al 2001).

Results Section

Statistical Analysis

The first step in statistical analyses was to determine weather or parametric tests could be conducted to examine the data. In order justify the use or nonuse of parametric tests; the assumptions underlying parametric tests were examined for each variable. In most cases these assumptions were met, however a Shapiro Wilks test did indicate that the variable Agreeableness was not normally distributed. A histogram did however contradict the Shapiro Wilks results for agreeableness. Moreover, the Skewness and Kurtosis of agreeableness were both under 2, -1.01 and 1.18 respectively. Therefore, parametric tests were employed to statistical analyses.

The next part of statistical analysis involved examining a possible correlation between dimensions of personality and alpha wave amplitude. In order to do this, a Pearson's correlation was used to flag any possible significant correlations. A Multiple regression was then used to examine if a combination of the dimensions were correlated with alpha wave amplitude in any of the conditions.

The next step was to analyze the affect that experimental manipulation had on each condition. In order to examine this, a repeated measures analyses of variance, (ANOVA) was used. The repeated measures ANOVA was able to indicate whether or not alpha wave amplitude differed significantly between each condition. Moreover, the repeated measure ANOVA was also used to indicate the power of the study.

Descriptive Statistics

Table 1.

Descriptive Statistics for Personality Dimensions

Variable	Mean	SD	Skewness	Kurtosis
Extraversion	3.57	.65	.16	-.79
Agreeableness	3.71	.65	-1.01	1.18
Conscientiousness	3.35	.77	-.23	-.78
Neuroticism	2.72	.91	.128	-.68
Agreeableness	3.62	.71	-.268	-.42

Note. SD = Standard Deviation.

Table 1 gives an overview of the data collected regarding dimensions of personality by presenting the means and standard deviations of each variable. The Skewness and Kurtosis of scores are also indicated. All Skewness and Kurtosis values indicate normal distributed data.

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Table 2.

Descriptive Statistics for EEG Microvolts

Variable	Mean	SD	Min	Max
Low Con (μV)	-.98	4.36	-9.82	8.5
Int Con (μV)	-.39	3.94	-6.82	14.17
High Con (μV)	-.05	3.66	-7.55	10.75

Note. SD = Standard Deviation. Con= Condition. μV = Microvolts. Min = Minimum Value. Max = Maximum Value

Table 2 gives an overview on the data collected regarding EEG micro voltage. This data suggests that as level of stimulus increases, micro voltage then in turn begins to approach a positive level with mean scores of -.98, -.39 and-.05 respectively. However, the intermittent condition does have a higher maximum score for micro voltage than the higher condition, with scores of 14.17 and 10.75 respectively. Moreover, the higher condition also has a lower minimum score than the moderate condition with scores of -7.55 and -6.82 respectively.

Table 3.

Descriptive Statistics for EEG Hz (8-13Hz)

Variable	Mean	SD	Min	Max
Low Con (Hz)	10.17	.14	9.81	10.45
Int Con (Hz)	10.21	.17	9.81	10.62
High Con (Hz)	10.13	.14	9.84	10.42

Note. SD = Standard Deviation. Con= Condition. μV = Microvolts. Min = Minimum Value. Max = Maximum Value

Table 3 then gives an overview of the amplitude of scores, measured in Hertz, within the alpha band (8-13Hz). This data suggests that the moderate condition provided the greatest amplitude between the three conditions, with low, moderate and high conditions scoring 10.17, 10.21 and 10.13 respectively. Moreover the maximum hertz score for the high condition was lower than that of both low and moderate condition. However the minimum score for the high condition was lower than that of the other two conditions.

Inferential Statistics

Persons Correlation

The mean scores for Agreeableness were 3.7 (SD = .65) and for alpha wave amplitude in the intermittent stimulus condition were 10.2 (SD =-.166) A Pearson's correlation coefficient found that there was a moderate positive significant relationship between Agreeableness and alpha wave activity in the intermittent stimulus condition (r (33) .4, p = .038) Therefore multiple regressions were used to test examine whether or not other personality traits correlated with alpha wave amplitude in other conditions.

Multiple Regression

Multiple Regressions were used to test whether the five dimensions of personality were predictors of alpha wave activity in low stimulus condition. The results of the regressions indicate that dimensions of personality account only for 3% of the variance, however this was not significant (R^2 = .03, *F* (5, 29), p = .559). Another multiple regrssion was then used to test whether or not the five dimensions of personality were predictors of alpha wave activity in the intermittent condition. The results of the regressions again inidcated that although agreeableness was correlated with the intermittent stiumulus condtion, overall the five dimensions only explianed 8% of the varience, however again this was not significant (R^2 = .08, *F* (5, 29), p = .205).

Finally the last multiple regression attempted to examine whether or not the Five dimensions of personality were predictors of alpha wave activity in high stimulus condition. The results of this regression indicated that dimensions of personality account for 10% of the varience, however this was again not seen to be significant. (R^2 = .1, *F* (5,29), p = 854). Therefore indicateing once again that personality dimensions are not significantly correlated to alpha wave activity.

The correlation coeffeients are further explained in Table 4.

Table 4.

Correlation of Dimensions of Personality and EEG

Variable	Low (Hz)	Intermittent (Hz)	High (Hz)
Extraversion	-.06	.07	-.12
Agreeableness	.28*	.35**	.07
Conscientiousness	.26*	.09	-.05
Neuroticism	-.06	-.07	.00
Openess	.07	-.18	-.19

*p significant at .1 level

**p significant at .05 level

Repeated Measures ANOVA

Therefore with results indicating that personality was not generally associated with A repeated measures ANOVA, using the Greenhouse-Geisser correction showed that the level of stimulus did not significantly differ between the three conditions, however it was approaching significance ($F(2, 64) = 2.907$, $p = .065$) with an effect size of .079. Pairwise Comparisons, also failed to demonstrate significant differences the high level of stimulus condition and the low level of stimulus condition (-.033, p=.88, CI (95%) -.112 - .045) however differences between the high stimulus condition and moderate stimulus condition were again approaching significance (.073, p=.097 CI (95%)-.155- .009).

Therefore it cannot be concluded that there was a significant difference in amplitude of alpha wave activity between the three groups. However, between the moderate and high conditions it was approaching significance. Moreover, this repeated measures ANOVA showed the observed power to be .533. Therefore if there was a true effect between conditions, this study had only a 53% chance of observing that effect.

Qualitative Data

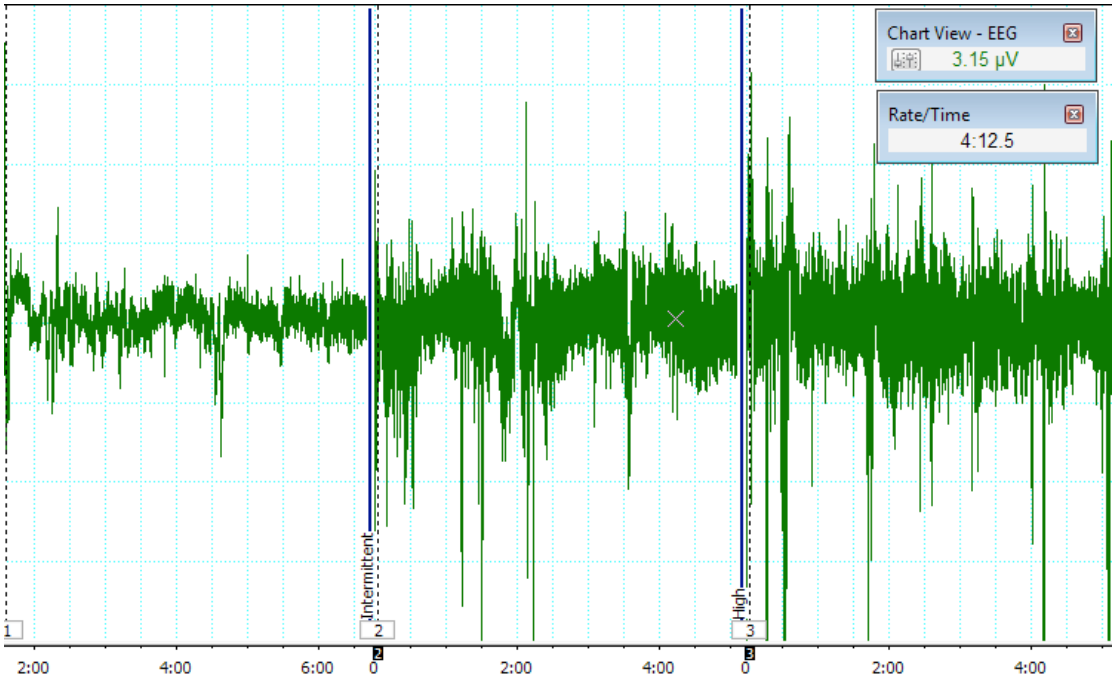

Figure 1

Note. The above reading is that of participant number 24. The gain set has been adjusted to 500:1

The micro voltage trend, demonstrated above, is typical of that of the sample. This image shows a higher micro voltage reading in the high level of stimulus. However this trend did not seem to be reflected in the statistical analyses.

Discussion Section.

Personality and alpha wave activity

The present study had several primary aims. In the broad form, the first aim of this study was to investigate a relationship between personality and alpha wave activity based on Eysenck's (1967) theory of the biological basis of personality. More specifically, however, this study aimed to examine whether particular dimensions of personality were individually linked to alpha wave activity. The results demonstrated a significant positive correlation between agreeableness and alpha wave activity, in the intermittent stimulus condition. However, none of the other dimensions showed a significant correlation with alpha wave activity, even when examined under different levels of stimulus. Therefore given these results it can be concluded that the study only somewhat verified the primary hypotheses, that is, that personality would be significantly associated with alpha wave activity.

In the case of agreeableness and alpha wave activity, the results loosely provide support for Eysenck's biological basis of personality (Eysenck, 1967, 1994). However, in the most recent explanation of the Eysenck's biological basis of personality, the biological differences were explained in terms of extraversion (Eysenck, 1994). Therefore the explanation for these differences was based on behaviors typically associated with extraverts. Thus it is difficult to apply these same processes to the dimension of agreeableness. However this does pose an interesting avenue of research for future studies, as there seems to be no biological explanation offered regarding alpha wave activity and agreeableness. If further research verifies this link, then it explanation of this correlation may be of interest to theorists in the field.

However, a certain level of caution must be applied when examining these results because previous research has not focused on the correlates of agreeableness and alpha wave activity, in an intermittent stimulus condition. Therefore it remains unknown weather the effect

in the present study is real or occurred by chance. Although, Tran et al (2006) did find a small but significant contribution made by agreeableness to both delta and theta wave activity. Tran et al (2006) however found this contribution in a low stimulus condition rather than the intermittent condition described in the present study. Therefore with such a small body of research investigating agreeableness and its alpha wave correlates, future studies should perhaps investigate this proposed link. It would be recommended further that future studies investigate this link under an intermittent stimulus with a large sample in order to increase accuracy of results.

However it is worth also noting that Eysenck (1994) did not include agreeableness as a dimension of personality. Eysenck (1994) treated agreeableness, along with conscientiousness, as a sub facet of psychoticism (John et al, 2010). The present study shows some justification for this as in the low stimulus condition results for conscientiousness and agreeableness were similar and both approaching significance. Nevertheless, there is a wealth of research to suggest that psychoticism is not significantly associated with alpha wave activity, in studies that use the PEN model (Gale, 1969; Gray, 1981; Savage 1964). Therefore this flags a possible issue with previous research, which is that studies that use the PEN model may be at risk of overlooking a link between agreeableness and alpha wave activity, as the it treats both as the one variable (John et al, 2010). For example, the present study showed no significant correlation between conscientiousness and alpha wave activity. However there was a positive moderate significant correlation between agreeableness and alpha wave activity.

Therefore this may also be another point of interest for future research. Henceforth this study suggests that future research should refrain from using the PEN Model of personality, and instead use the Five Factor Model as it splits psychoticism into two separate dimensions.

This may be another possible reason why there is such a small body of research investigating agreeableness and personality.

Gales Hypothesis

Another primary aim of this study regarded Gales intermittent condition hypothesis (1973). This aim was basically to investigate if Gale's (1973) reasoning, which has been adopted by several other studies, such as Hagemann & Naumann (2009), was in fact justifiable. Therefore this study attempted to investigate dimensions of personality over three different conditions in order to see whether there was just cause for only using an intermittent level of stimulus in studies examining alpha wave activity and dimensions of personality. None of the dimensions showed a significant correlation with alpha wave activity in the either the high or low condition of stimulus. Moreover, the only significant result was observed was with agreeableness intermittent condition. Statistical analysis did, however, indicate that the differences in alpha wave activity, between each condition, were only approaching significance. Thus, it may be suggested that there wasn't enough stimulus change between each condition.

Nevertheless, Gale's (1973) hypothesis is supported by the results of the present study. Interestingly however Gale devised this optimum condition with specific regard to extraversion not agreeableness. In fact Gale (1973) had used the PEN model of personality in all previous research prior to suggesting this condition therefore agreeableness was not a variable he had considered but was still only a sub facet of psychoticism (Gale 1973, 1983; Gale et al, 1967). Yet study still found that an intermittent level of stimulus was to be the optimum condition for observing a correlation between alpha wave activity and agreeableness. Therefore these results provide huge amount of support for Gale's (1973) hypothesis. Henceforth, the general conclusion of the present study is that an intermittent level of stimulus provides the optimum

condition for observing correlations between dimensions of personality and alpha wave activity.

Again, this conclusion must be interpreted with a degree of caution. For instance statistical analyses showed that mean frequency of scores between 8-13Hz levels were greater in the intermittent stimulus condition, than in the high condition. Therefore these results may suggest that the high condition of stimulus, which was characterized by a Stoop Test, did not actually provide a heightened level of stimulus. These results are somewhat puzzling as there is a wealth of research to suggest that Stroop interference is a useful measure of frontal lobe function (Stuss et al, 2001). Moreover qualitative EEG data suggested a greater amount of alpha wave activity in the stoop condition. Although statistical analyses did also indicate that the power of the present study was only 50%. Therefore if there was a significant difference in alpha wave frequency between the conditions this study had a 50% chance of not observing that effect.

Nonetheless, future research may find it useful to employ another method of stimulation for the frontal lobes, if the goal is comparing conditions. However the recommendation of the present study remains that future research should primarily follow Gale's (1973) hypothesis. Moreover, in terms of increasing the power of future studies, perhaps lager sample sizes are needed. This would then give the study a greater power value which in turn should indicate a greater chance of observing an effect if one were present.

EEG and extraversion

Another major aim of this study was to investigate a correlation between extraversion and alpha wave activity. The results indicated that there was no significant relationship between extraversion and alpha wave activity in any of the conditions. Therefore the results indicate that

the hypothesis that predicts a correlation between extraversion and alpha wave activity should be rejected.

Eysenck (1994) refined his original biological basis of personality to primarily account for a link between extraversion and alpha wave activity. Briefly, Eysenck (1994) maintained that the biological basis of extraversion was primarily due to differences in cortical arousal. Eysenck (1994) further maintained that these differences were as a result of differences in structure and function of the reticular activating system (ARAS). If this hypothesis were shown to be correct then it would be accepted then it would be expected that people who score high on the extraversion dimension would have a lower amplitude and higher frequency of alpha wave activity. However the present study failed to support this.

Therefore the current study adopts that stance that extraversion is not significantly correlated with alpha wave activity. These results are supported by previous research such as Fenton & Scott (1967) and Hagemann & Naumann (2009). However this viewpoint faces a wealth of opposition, as there is a vast body of research to suggest a link between extraversion and alpha wave activity (Eysenck, 1994, 1983, 1967, Savage, 1964; Wall, Schuckit Mungus & Ehlers 1990;Tran et al, 2006; Tran et al, 2001; Zuckerman 1991). However, Eysenck (1994) does concede that due to external factors, correlations between extraversion are likely to be only weak to moderate if they are observed. Although in contrast to this, Hagemann & Naumann (2009) maintain that these external factors, proposed by Eysenck (1994), do not significantly affect EEG data. However it may be something to consider for future research.

Overall the results of the present study are generally in contrast to that of previous research. Therefore it is important to consider the limitations that may have affected the results such as equipment, facilities and sample. For instance, the laboratory, where the experiments were conducted, was situated beside a classroom and was not sound proofed. Therefore the

present study considers this as a major limitation, as the experimenter could not fully control external auditory stimuli. Earplugs were however given to each participant in an attempt to control for this external auditory stimulus. Although due to the nature of the study and the interaction between the experimenter and the participant, these earplugs were not noise cancelling but were instead noise muffling. In a further attempt to control for this artifacts were removed from the EEG analyses and the data was smoothed in an attempt to control for noise. Nevertheless, this is still considered a major limitation of the present study and it is recommended that future studies use a sound proofed EEG laboratory.

Another possible limitation of the study is that the experiment neglected to control for caffeine consumption. Research suggests that withdrawal of dietary caffeine may alter quantitative EEG readings (Jones, Herning, Cadet & Griffiths, 2000). However Keane & James (2008) maintain that caffeine consumption has no significant effect on EEG within the alpha band. Therefore the present study determines that caffeine consumption may not have significantly affected EEG readings, however there may be a possible link between dietary caffeine withdrawal and alterations in EEG readings. Henceforth the present study suggests that daily dietary caffeine consumption should be assessed in future studies. In order to do this both dietary consumption and last known consumption should be recorded.

Frontal lobes and alpha wave activity

The final hypothesis proposed that the frontal lobes were an appropriate location to record alpha wave activity from. However, determining acceptance or rejection of this hypothesis proves challenging. For example, the statistical analyses demonstrated clear alpha readings from the frontal lobes. Therefore it would seem that the hypothesis was accepted. However, with the lack of an observed correlation between alpha wave activity and

extraversion, which was been demonstrated in numerous studies, it remains likely that there was an issue with recording alpha wave activity from this location.

For instance, much of the research within the field examines alpha waves primarily from the posterior regions of the brain (e.g. Savage, 1964). In support of this view, Neidermeyer (1987) suggests that maintains that alpha wave activity should be primarily measured from the posterior regions of the brain, as alpha readings in the frontal regions are typically low. The present study however recorded data from the frontal regions. This decision was made due to the large body of research that suggests a link between frontal cortical regions and personality (Cummings, 1993; Meyers et al, 1992; Sundram et al 2012). Moreover this decision was further supported by the research of Tran et al (2001) who adopted a similar approach to recording alpha wave activity. However Tran et al (2001) found a significant relationship between extraversion and alpha wave activity whereas the present study obviously did not. Therefore perhaps the present study should have focused on the posterior regions, rather than the frontal. On the other hand, if that were the case then it would perhaps be unlikely that a relationship was found in the between the alpha waves and another dimension i.e. agreeableness. Therefore it is difficult to either accept or reject the initial hypothesis. Henceforth, future research should perhaps further investigate alpha wave activity in the frontal lobes. It may also be useful for future research to compare alpha wave activity between the posterior and frontal regions.

Future of EEG in personality psychology

The results of this study indicate that EEG may still be an effective way of examining personality. Therefore it is suggested that EEG should remain as the standard measures of cortical arousal and personality. However, the present study also suggests that, perhaps EEG should be used in conjunction with neuroimaging techniques and genetic

microarrays in future research. The proposed use of multiple techniques may give researchers a better insight into the root cause for differences in personality.

Conclusion

In conclusion, the present study raises some interesting questions about the link between alpha wave activity and dimensions of personality. A moderate positive correlation was observed between agreeableness and alpha wave activity, however due to the lack of a correlation between extraversion and alpha wave activity some caution must be applied when interpreting these results. Nevertheless the results of this study indicate that differences in cortical arousal do not significantly reflect differences in level of extraversion. It further concluded that the Five Factor Model might be a useful tool for future research in comparison to other models, given the correlation between agreeableness and alpha wave activity. This study also supported Gale's (1973) hypothesis regarding intermittent condition stimulus, as significant results were seen only in the intermittent stimulus condition. Therefore this study suggests that future research uses the experimental design describes by Gale et al (1967).

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Appendix

Consent Form

Dublin Business School
Psychology Department
13-14 Aungier Street
Dublin 2.

Please Note: All participants taking part in this study must be over 18 years of age.

Firstly, thank you for considering taking part in my study my name is Barry Coughlan. I am currently in my final year of my BA(Hons) Psychology degree in Dublin Business School. The areas of psychology, which I am most interested in are personality and neuropsychology. Therefore for my research project I would like to invite you to take part in my study, which aims examine the relationship between personality and brainwave activity.
During this study you will be asked to fill out two short questionnaires and have your EEG measured. Whilst you are having your EEG measured you will be asked to follow certain commands including opening and closing your eyes and completing a cognitive task.

The total time for completion of this study is approximately twenty minutes.

Benefits of this study will include the contribution of knowledge to the area of personality neuroscience.
There is minimal risk associated with this study, however some participants may feel some discomfort whilst answering some questions on the questionnaire or whilst their EEG is being measured.

Your participation in this study is completely voluntary. You have the right to refuse to complete the study, leave or have your data discarded at any point in the study. You should also feel free to ask the researcher any questions that arise throughout the study.
Your data may be used in my final year project and possible further publications however you will not be in any way identifiable by your data and no personal information you give the researcher will be recorded or used, apart from your demographic information.

If you have any questions that have arisen following this study, or have any enquires about the findings of this research feel free to contact me via my email:

Statement of consent:

I have read the above information and I understand the experimental procedure and what's involved in this study. I consent to participate in this study.

[ ] (**please tick here if you consent to take part in this study**)

Debriefing Form

Thank you for your participation in this research.

If answering any of the questions on the questionnaires lead you to feel distressed and you would like to talk to someone please contact one of the following organizations:

- Samaritans- 1850 60 90 90
- Aware – 1890 303 302
- Recovery international Ireland – 01 6260775

If you have any inquires regarding the research itself, findings or possible publications please feel free to contact me via email:

If you are interested in the area, then you may wish to read the following:

Eysenck, H.J. (1994) Personality: Biological foundations. In P.A Vernon (Ed.), *The neuropsychology of the individual differences* (pp.151-207) San Diego: Academic Press.

Demographics Questionnaire

Demographic Questionnaire

Please indicate the correct answer with an "x" in the appropriate box in each case

Gender:

Male [ ]

Female [ ]

Age:

18- 22 [ ]

23- 27 [ ]

28-32 [ ]

33 + [ ]

Right or left handed:

Right [ ]

Left [ ]

Current Status:

Undergraduate [ ]

Postgraduate [ ]

Other [ ]

Big Five Inventory.

How I am in general

Here are a number of characteristics that may or may not apply to you. For example, do you agree that you are someone who *likes to spend time with others*? Please write a number next to each statement to indicate the extent to which **you agree or disagree with that statement.**

1 Disagree Strongly	**2** Disagree a little	**3** Neither agree nor disagree	**4** Agree a little	**5** Agree strongly

I am someone who…

1. _____ Is talkative
2. _____ Tends to find fault with others
3. _____ Does a thorough job
4. _____ Is depressed, blue
5. _____ Is original, comes up with new ideas
6. _____ Is reserved
7. _____ Is helpful and unselfish with others
8. _____ Can be somewhat careless
9. _____ Is relaxed, handles stress well.
10. _____ Is curious about many different things
11. _____ Is full of energy
12. _____ Starts quarrels with others
13. _____ Is a reliable worker
14. _____ Can be tense
15. _____ Is ingenious, a deep thinker
16. _____ Generates a lot of enthusiasm
17. _____ Has a forgiving nature
18. _____ Tends to be disorganized
19. _____ Worries a lot
20. _____ Has an active imagination
21. _____ Tends to be quiet
22. _____ Is generally trusting
23. _____ Tends to be lazy
24. _____ Is emotionally stable, not easily upset
25. _____ Is inventive
26. _____ Has an assertive personality
27. _____ Can be cold and aloof
28. _____ Perseveres until the task is finished
29. _____ Can be moody
30. _____ Values artistic, aesthetic experiences

31. _____ Is sometimes shy, inhibited

32. _____ Is considerate and kind to almost everyone

33. _____ Does things efficiently

34. _____ Remains calm in tense situations

35. _____ Prefers work that is routine

36. _____ Is outgoing, sociable

37. _____ Is sometimes rude to others

38. _____ Makes plans and follows through with them

39. _____ Gets nervous easily

40. _____ Likes to reflect, play with ideas

41. _____ Has few artistic interests

42. _____ Likes to cooperate with others

43. _____ Is easily distracted

44. _____ Is sophisticated in art, music, or literature