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International Journal of Psychophysiology 41 (2001) 87–91

INTERNATIONAL
JOURNAL OF
PSYCHOPHYSIOLOGY

www.elsevier.nl/locate/ijpsycho

Short communication

Psychophysiological correlates of the NEO PI-R Openness, Agreeableness and Conscientiousness: preliminary results

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Received 16 August 2000; received in revised form 4 October 2000; accepted 9 October 2000

Abstract

Eysenck (1983) has previously proposed biological mechanisms for his three personality dimensions. From a psychometric perspective there has been a growing acceptance of a five-factor model of personality incorporating two of Eysenck's dimensions Extraversion (E) and Neuroticism (N) together with Openness to Experience (O), Agreeableness (A) and Conscientiousness (C). Despite the growing acceptance of the 'Big 5' model of personality there has been very few studies that have examined the biological basis of O, A and C. In an exploratory study we report the correlations between photic driving at alpha, beta-1, beta-2, delta and theta bands and O, A and C from the NEO PI-R in 16 participants. Significant correlations between the EEG at frontal, occipital–parietal and central–temporal areas at different driving frequencies with O, A and C are discussed. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Photic driving; Personality; Big 5; Openness to experience; Agreeableness; Conscientiousness; EEG

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PII: S0167-8760(00)00176-8

1. Introduction

Eysenck has previously described his three main personality dimensions; extraversion/introversion (E), neuroticism (N) and psychoticism (P) arguing that these two super-factors are consistently found in large studies on trait personality, usually from factor analysis of questionnaire data. A third factor termed Psychoticism (P) was later introduced by Eysenck to form the third super factor derived from the Eysenck Personality Questionnaire (Eysenck and Eysenck, 1976). It may be noted, however, that the existence of the third factor, P, has been the focus of continued and considerable debate. Costa and McCrae (1992) have posited an alternative model of personality, identifying and delineating five dimensions of personality. Together with E and N, Costa and McCrae also integrate Openness to Experience (O), Agreeableness (A) and Conscientiousness (C) within their five-factor model (FFM) of personality.

Eysenck has described the physiological basis of E and N in several reports (1983). According to Eysenck's model, extraversion–introversion differences are largely determined by activity in the reticular formation–cortex arousal loop with introverts hypothesised to have greater resting cortical arousal than extraverts so that they show greater arousability than extraverts to stimuli of weak intensity. Individual differences in N are held to be due to differences in limbic system functioning. In terms of the differences between Eysenck's and Costa and McCrae's model of personality, Eysenck has argued that the existence and ultimately the acceptance of one particular model of personality over another should be based on evidence accumulated at a biological level (Eysenck, 1980). Biological research should provide some level of construct validity for hypothesised dimensions of personality. Whilst Costa and McCrae's FFM of personality has received much empirical (Piedmont and Weinstein, 1993) and popular support, there has been little research examining biological correlates of their dimensions apart from E and N established by Eysenck. The present paper therefore examines for the first time the relationship between photic driving, and O, A and C from Costa and McCrae's FFM of personality. As this is the first empirical attempt at correlating photic driving at different EEG bands with the FFM of personality no specific hypotheses were made.

2. Participants

Participants were five males and 11 females, aged between 20 and 30 years (mean = 22.75, S.D. = 3.8).

3. Procedure

Participants were requested to abstain from alcohol for 24 h prior and from nicotine and caffeine for 2 h prior to testing. Each participant was given a brief description of the procedure and provided written informed consent. Exclusion criteria included any history of concussion or familial psychiatric illness. The subjects then completed the full version of the NEO PI-R followed by the photic driving tasks. An electrode cap measuring 20 sites according to the International 10–20 system was used and referenced to linked earlobes. The electrodes were connected via a headbox to a Medelec DG Discovery EEG/photic driving machine and electrical potentials for all sites were recorded during different sequences of photic stimulation (described below). All impedances were below 10 kΩ and the EEG filter excluded frequencies outside a bandwidth of 0.16–50 Hz. The subjects were placed 1 m from the light box and kept their eyes closed throughout the experiment. Each subject was exposed to the same photic sequence: 30 s of 12, 26, 4, 16, 9, 40, 8, 30, 18, 10 and 13 Hz light with a 90-s break between each. The light intensity was 7.2 cd/m^2.

4. EEG analysis

EEG data was analysed using the Medelec DG Discovery Series Power Spectrum Analysis. The last 15-s epoch of photic stimulation for each frequency was analysed using an in-built fast Fourier transform program. A calculation was thus made of the percentage of waveform within the overall EEG which corresponded to the frequency of stimulation.

For the purposes of this study, the EEG bands were defined as delta (0.1–3.9 Hz), theta (4.0–7.9 Hz), alpha (8.0–12.9 Hz), beta-1 (13.0–19.9 Hz) and beta-2 (20.0–32.0 Hz). Recordings were also made with 40 Hz of stimulation, however, only one subject showed corresponding EEG at this frequency so this band (gamma) was disregarded for the rest of the experiment. In order to condense the EEG output data averages within each band were calculated. As a limited number of photic driving frequencies were used in the current study, theta was represented by the output from 4 Hz stimulation frequency, alpha by the mean of 8, 9, 10 and 12 Hz, beta-1 by the mean of 13, 16 and 18 Hz and beta-2 by the mean of 26 and 30 Hz stimulation. In order to localise photic driving functions the electrode sites were grouped into four cortical regions and the average corresponding EEG output for each stimulation frequency within these areas was used. The frontal region consisted of sites FP_1, FP_2, F_3, F_4, F_7, F_8 and F_z. The occipito–parietal region was P_3, P_4, O_1, O_2, P_z and PO_z. The left and right central–temporal areas were C_3, T_3 and T_5, and C_4, T_4 and T_6, respectively. C_z was not used in analyses. These averages were calculated in order to reduce the number of correlations calculated. The aim of the present study was to examine the pattern of correlations between the personality and photic driving variables in order to determine whether future research with larger samples is warranted. Within this context the status of significant correlations should be regarded as preliminary awaiting further replication.

The mean scores for openness, agreeableness and conscientiousness were calculated and it was found that this sample, according to the norms provided by Costa and McCrae (1992), were high in O (M = 130.4, S.D. = 19.1), low in A (M = 115.7, S.D. = 23.5) and C (M = 107.5, S.D. = 16.5) and reflected a good distribution of scores on these three dimensions.

Correlations between the percentage of output corresponding to photic stimulation for each band and cortical region with scores in the O, A and C domains of the NEO PI-R were calculated and are shown in Table 1. Given the small sample size, correlations that showed a significance of less than 0.1 were considered important. Although the NEO PI-R also assesses E and N, correlations between these two dimensions and the photic driving data were not calculated because the relationship between photic driving and these two dimensions have been previously studied and to reduce the number of correlations calculated. As this was an exploratory study, corrections for multiple comparisons were not made. Correction for multiple comparisons could be made in future research after determining the extent to which the different EEG variables are independent within the context of a study assessing psychophysiological correlates of personality dimensions.

O was moderately and positively correlated with photic driving at a frequency in the theta band across all cortical regions; A was moderately and negatively correlated with photic driving at frequencies in the beta-1 band in the left

Table 1
Correlations between NEO PI-R scores in openness, agreeableness and conscientiousness with photic driving power for different EEG bands in four cortical regions[a]

	Theta	Alpha	Beta-1	Beta-2
Openness				
Frontal	**0.52***	0.25	0.29	0.19
Occipito–parietal	**0.52***	0.07	0.24	0.16
Left central–temporal	**0.53***	0.03	0.26	0.29
Right central–temporal	**0.52***	0.13	0.26	0.30
Agreeableness				
Frontal	0.19	0.25	0.29	0.01
Occipito–parietal	0.10	0.33	0.11	0.21
Left central–temporal	0.15	0.31	**0.43#**	0.03
Right central–temporal	0.22	0.32	0.26	0.09
Conscientiousness				
Frontal	**0.48**	0.04	0.42	0.16
Occipito–parietal	0.23	0.18	**0.50***	0.18
Left central–temporal	0.36	0.06	**0.50***	0.29
Right central–temporal	0.35	0.02	**0.48#**	0.25

[a] Significance: $^{*}P < 0.05$; $\#P < 0.1$.

central–temporal region; and C was moderately and negatively correlated with photic driving at frequencies in the theta band frontally, and moderately and positively correlated with photic driving at frequencies in the beta-1 band in occipito–parietal and left and right central–temporal regions.

The most pertinent finding was the positive correlation between openness scores and the percentage of EEG theta output corresponding to photic driving in the theta band for all cortical regions, suggesting that individuals with higher scores in NEO PI-R O tend to have a greater amount of theta production. Several studies have reported that theta driving decreases as a function of age (Yaguchi, 1983) and that theta activity is associated with direct pleasure-seeking (Kugler and Laub, 1971; Maulsby, 1971). Walter (1953) also postulated that theta activity is involved in scanning for pleasure as pleasure fades. These deductions, when considered in the context of the present investigation, lead one to speculate that O may involve processes that exist foremost in childhood and diminish during development. Those adults who are more open, according to the NEO PI-R, may have retained a somewhat childlike wonderment and open-mindedness about their world with a willingness to explore alternative views about issues. On the other hand, those who are not so open may have succumbed to more narrow-minded thought habits as a result of their developmental environment or even their particular genetic blend.

A was negatively correlated with the proportion of EEG beta-1 output in the left central–temporal region stimulated by photic driving in the beta-1 band. Beta-1 activity has previously been associated with anxiety (Shagass, 1955; Ulett et al., 1953), as well as with individuals described as quick, impulsive, variable and highly stimulable (Mundy-Castle, 1953). The fact that the present study revealed a negative correlation between beta-1 and A supports this previous research, as it could be considered that individuals higher in A may be less impulsive, variable and stimulable. That the finding was only significant in one area of the cortex when the other areas were not correlated requires further investigation. Future research may determine whether agreeableness is a personality domain that can be localised to the left central–temporal region or is contributed to by diffusely located neural networks.

C was correlated with two EEG bands but in different areas and in different directions. Firstly, the percentage of EEG theta output in the frontal region from photic driving in this band was negatively correlated with conscientiousness. As previously discussed, theta activity has been shown to be elevated for children compared to adults, therefore the current finding may also relate to the maturity of individuals. It would be conceivable to assume that those individuals with higher levels of theta (lower in maturity) would be lower in conscientiousness. This was somewhat supported in that all the correlations in this band were negative, however, this must be interpreted with caution as the correlations for areas other than the frontal region were not significant. The second finding relating to conscientiousness was that of a positive correlation between this personality domain and EEG beta-1 output from corresponding photic stimulation for the occipito–parietal and left and right central–temporal cortical regions. This may not be consistent with some previous research on beta-1 photic stimulation, as it would be counter-intuitive to connect traits such as anxiety, impulsivity, variability and stimulability with C. Subsequent research may be able to clarify this paradox, although it is feasible that an individual could be conscientious and simultaneously display these other traits, particularly anxiety. Future research employing larger samples is required to more clearly examine these preliminary and provocative relationships.

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