청각 EPR의 내외생적 요소들과 성격의 상관에 관한 연구

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Correlations of Exogenous and Endogenous Components of Auditory ERPs to Psychometric Measures of Personality

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Abstract

본 실험은 청각 사상관련전위(ERP)를 이용하여 다양한 성격 특질 모형들의 생물학적 근거와, 구조의 공통점과 차이점을 명확히 하기 위해서 설계되었다. 48명의 대학생 피험자들에게 4가지 성격 측정 검사(NEO-PI-R, EPQ-R, BIS/BAS 척도, IVE)를 시행하고, 이어 두 종류의 청각 자극 세트(50ms와 300ms)를 이용한 오드볼 과제를 통해 ERP를 측정하였다. 설문지 간의 상관과, 설문지와 ERP 내외생적 구성 요소 간의 상관, 그리고 그 상관의 두피 분포 양상을 통합적으로 고려하여 해석하였다.

각 성격 검사의 외향성 척도에 해당한다 할 수 있는 *E*, E, BAS-FUN은 양성 모두에서 높은 수준의 설문지 척도 간 정적 상관을 보였으나, 50ms 자극으로 유발된 P3 진폭은 E와 BAS-FUN에 대해서만 유의하게 높은 상관을 나타내었다. 이 결과는 Eysenck의 모델과 일견 일치하는 결과이지만, 그가 개발한 EPQ-R의 외향성 척도(*E*) 보다는 오히려 다른 척도들이 뇌파에 반영된 성격의 생물학적 기제를 측정하기 위한 적절한 도구일 수도 있음을 시사한다.

신경증적 경향성을 반영하는 *N*과 N 척도는 50ms 자극에 대한 여성 피험자의 N1, P2 진폭과 유의한 상관을 보였다. 그러나 이론적으로 두 척도에 등가적인 것으로 예상되었던 BIS 척도는 설문지 간 상관이나 ERP 요소와의 상관에서 모두 유의한 결과를 보이지 않았다.

Eysenck가 성격의 세 번째 축(차원)으로 제시했던 *P*(정신병적 경향성) 역시 여성 피험자들에게서 두드러지는 설문지 간 상관을 보였으나, 300ms 자극에 대한 P2 진폭과의 정적인 상관은 양성을 합한 자료에서만 발견되었다. 여성의 상관 분포는 비록 통계적으로 유의한 수준에는 이르지 못하였으나, 양성 자료의 분포와 유사함이 확인되었다.

이 실험의 결과는 P3 진폭과 외향성 간의 부적인 상관 관계를 보고하였던 기존 연구들을 지지한다. 또한 본 실험에서 확인된 Eysenck 모델의 신경증적 경향성이나 정신병적 경향성이 ERP의

비교적 초기에 나타나는 외생적 구성 요소들(N1, P2)과의 상관 양상은, P3 요소에 집중하였던 기존 연구들이 외향성 이외의 차원으로 일관된 결과를 얻어내지 못했던 이유를 설명해줄 수 있을 것이다. 또한 성격 차원과 그것을 지표 하는 ERP 구성 요소 간의 관계를 해석할 때에 성별이나 유발 자극의 속성을 고려해야 함을 보여준다.

Keyword: Personality, ERP, oddball, Eysenck, EPQ-I, N1, P2, P3

1. Introduction

The interest of personality theorists is moving from descriptive classification of the fundamental dimensions to causal models that can explain their biological bases. This study was proposed as an exploratory study for understanding the biological bases and structures of three personality models; Eysenck's PEN model (Psychoticism (*P*), Extraversion (*E*), and Neuroticism (*N*); Eysenck & Eysenck, 1985), Gray's BIS/BAS model (BIS, BAS-FUN, BAS-REW, BAS-DRI, and BAS; Gray, 1981), and Costa & McCrae's Five Factor Model (Neuroticism (N), Extraversion (E), Openness (O), Agreeableness (A), and Conscientiousness (C); Costa & McCrae, 1992).

Concerning personality, most reports have explored the relationships between P300 and the introversion-extraversion of Eysenck theory because of its putative biological bases. General consensus is that introverts are supposed to produce larger P300 amplitude (Polich and Martin, 1992); not enough data, however, are available on the possible relationship between personality traits and either automatic attention or early sensory processing (Hansenne, *et al.*, 2002; in print).

The present study was proposed to investigate the correlations of the principal dimensions of the major personality theories with psychophysiological measure; auditory ERPs.

First, on the base of Eysenck' s PEN model, *E* and *N* dimension were compared with their equivalences of other models at the level of questionnaire correlation; E and N of NEO-PI-R, and BAS/BIS dimensions respectively. The contentious third dimension, psychoticism, was also focused on in point of the relative position in the correlation; for this purpose IVE was added, which involved impulsivity and venturesomenss as subscales.

Psychophysiological data helped to verify these correlations: the earlier sensory components of ERP (N1, P2) and latter cognitive component (P3) were induced by auditory oddball tasks. If the ERP correlation pattern revealed differences from inter-personality tests, it might imply different biological bases. This combined analysis would suggest an integrative perspective on understanding the relationship of three major personality dimensions, and the manifestation of their biological mechanism. Distributional topography of correlation coefficients was also taken into consideration to assess the relationships of psychometric measures.

2. Method

48 undergraduate students (28 males and 20 females), all in their early twenties (Mean = 21.10, SD = 2.13), served as subjects. In advance of ERP recording, all subjects completed four personality tests (EPQ-I, NEO-PI-R, BIS/BAS scale, & IVE). EEG activity was recorded by Grass Model 12 at the Fz, Cz, Pz, F3, F4, P3, P4 electrode sites of international 10-20 system using gold-plated electrodes affixed with electrode paste. The EEG was digitized at 250 Hz for 1200 ms with a 100 ms pre-stimulus baseline and filtered online through hardware bandpass filter at 0.1-100 Hz. These data were filtered again offline by Butterworth filter function of LabVIEW 6.*i* at 0.1-30 Hz. Trials in which the absolute value of EEG was over 50μV were rejected automatically in the analysis procedure.

ERPs were elicited with 1,000 Hz (standard) and 1,500 Hz (target) tones presented through two speakers at 80 dB SPL (Sound Pressure Level). Each stimulus was presented at the ratio of 75% and 25%. Two tasks were characterized by different stimulus presenting durations. In 50ms-Condition (called 'task 1' below), auditory stimuli were presented with 50ms duration, and in the 300ms-Condition (called 'task 2' below), with 300ms duration. Because durations of all the trials in two types of tasks were the same (1,500ms), ISI varied depending upon the task type. Table 2 summarizes the latency window for the each component induced by the tasks.

Table1. Latency Window for each ERP Component.

ERP Component	Latency window
N100 (**N1**)	170-260 ms
P200 (**P2**)	260-420 ms
P300 (**P3**)	400-650 ms

The statistical analyses were performed using SPSS 10.0 for Windows. First, repeated-measures analysis of variance (ANOVA) was used to evaluate amplitude and latency at the seven sites for each ERP component from two tasks. Greenhouse-Geisser corrections were employed to the degree of freedom to adjust for violations of the sphericity assumption in repeated-measures designs with three or more levels.

Second, relationships between ERP components and the personality dimensions obtained by psychological tests were assessed by use of the Pearson Correlation coefficients.

On the back of these statistical analyses, topographic maps of the skull were drawn based on the quantitative distribution of ERP components and their correlation coefficients with personality traits, and were considered to identify the pattern of relationships more clearly.

3. Results

Two types of tasks induced traditional auditory ERP waveforms, and they are presented in figure 1,

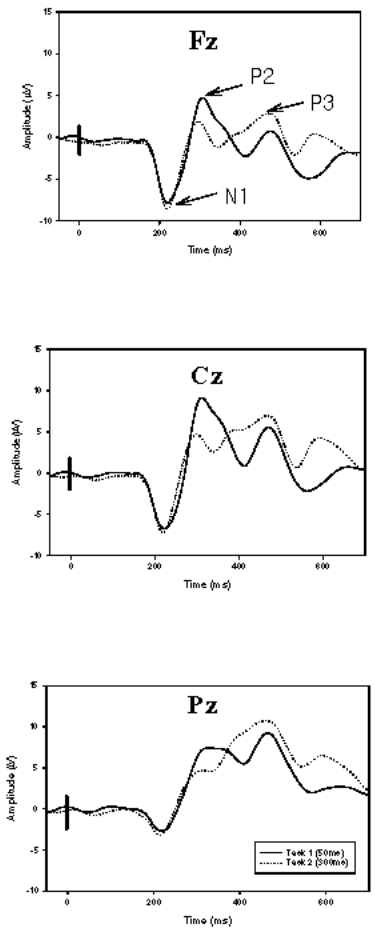

Figure 1. ERP Waveforms from Scalp Midline

Durations of auditory stimulus did not affect distributional topographies of P2 and P3 amplitudes and latencies intrinsically. The difference of stimulus duration, however, affected the mean values of amplitudes and latencies for P2 and P3, but not N1.

Subject mean scores and their SD were examined according to the validated references. Most subscales showed considerably high Cronbach's α value.

All psychometric measures of the personality tests were analyzed in male, female, and co-gender conditions separately and were compared. In the cross-correlational matrices, similarities and differences of two gender groups were identified. Positive correlations of BAS and its subscales were found in both genders, but only males showed significant correlations of intra-BAS subscales. As the equivalences of extraversion trait for each battery, *E*; E and BAS, revealed similar intra-correlations. *N* and N were also positively related in both genders, but the expected relationship with BIS was not found. Correlations to *P* were found only in females. In co-gender correlation matrices, trends of each gender were mixed and reflected.

Correlations of psychometric measure and exogenous and endogenous ERP components were analyzed out of consideration for their topographical maps. Stimulus conditions induced the salient differences in the correlations for each gender group.

In the amplitude of N1 component, female subjects showed overall distribution of negative correlation with Ven in both task. There were also negative correlations with *N* and N in females only for task 2.

Ven was negatively related to P2 amplitude with frontal maximal distribution in co-gender and female subjects for both tasks. *N* and N were negatively related in females with similarly parietal maximal

distribution for task 1. *P* revealed a parietal maximal distribution of positive correlations in co-gender for task 2; in females, even though it did not reach significant α level, its distribution was also analogous.

P3 amplitude had negative relationships with E and BAS-FUN in all gender conditions for task 1; the only exception was a nonsignificant distribution of BAS-FUN and P3 amplitude in males in spite of its similarity to the others. For task 2, only male subjects showed overall negative distribution of correlation coefficients with *E* and E. Figure 2 illustrates how this negative correlation was reflected to ERP waveforms. Latencies of ERP components were analyzed in the same manner with amplitudes. N1 latency was positively related to *N* and N in males for task 1, and negatively related to *E* and E in females for task 1. BAS DRI was positively related to N1 latency in all gender conditions. In the co-gender group, these trends were added and reflected. The only trait measure that had consistent relationships with all genders conditions for P2 latency was A. Female subjects showed a negative relationship with P2 latency for task 1; in male and co-gender subjects, this relationship was found for task 2. Despite some significant relationships with P3 latency, consistent trends were not found.

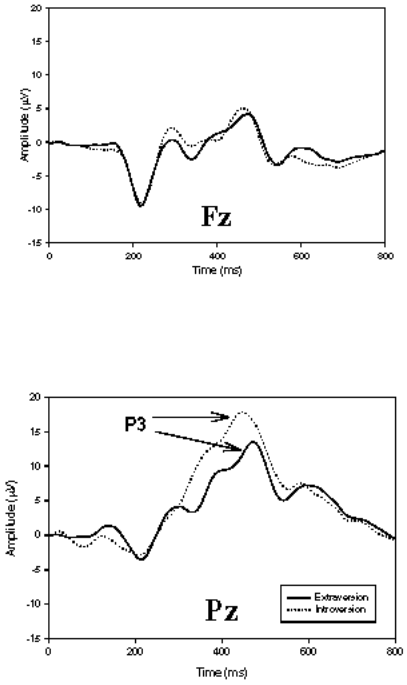

Figure 2. Grand average ERPs at Fz and Pz sites from introversion/extraversion groups for task 1. As shown in figure 12, negative correlation of E and P3 amplitude was higher at parietal area, and lower at frontal area. P3 amplitudes showed the consistent tendency, which introverted subjects' P3 amplitude was higher at parietal sites. Each group was classified according to the extremely polarized E score of NEO-PI-R, and their data were averaged separately (N=8 for extraversion, and N=9 for introversion). Baseline is omitted and P3 peaks appear with approximately 470 ms latencies.

4. Discussion

Eysenck's arousal hypothesis was remarkable on the point of view that it assumed biological differences would be the cause of personal differences (Eysenck, 1967). Even though his hypothesis was based on the conceptual mechanism in 1960, along with development of psychophysiological measures, it has inspired a number of researchers. Overall, these works constituted an important step toward a comprehensive understanding of personality.

Among the various psychophysiological approaches, apparently, ERP is very

suitable for this purpose. This is because the most modern major personality theories relating to biological bases emphasize the differences in sensory processing and higher cognitive function. ERP has been used to index variation in a broad range of human abilities in intact normal subjects. Rrecent studies have been concentrated on the possible relationship between introversion/extraversion dimension and P3 component. A consistent result of the studies that relate to P3 is that introverts exhibit higher P3 amplitude than extraverts (Brocke, Tasche, & Beauducel, 1996; Polich & Martin, 1992). Since P3 reflects controlled cognitive processes, these studies evidenced that some personality dimensions induced different controlled cognitive attitude towards the processing of information (Hansenne, *at al.*, 2002, in print).

The aim of this study was to investigate the correlations of the principal dimensions of the representative personality theories with psychophysiological measures: auditory ERPs from oddball tasks. The uniqueness of this study was the usage of distributional topographies for a solid understanding of the correlation between ERP components and personality measures.

48 undergraduate students participated as subjects in this study, and were assessed with four personality batteries. Comparison of acquired questionnaire data with normative samples from validated references demonstrated similar results. All psychometric measures showed fairly high Cronbach's α.

For the physical factor of auditory stimulus, both tasks induced the traditional ERP waveform. ERP components from both tasks showed very similar distributions of amplitudes and latencies, and they were also correspondent to their typical distributions.

This exploratory study had the potential problem of increased α level. To avoid this problematic situation, consistency of the correlations among seven electrode sites and their topographical mapping patterns were considered as secondary criteria for judging of noteworthiness. Even though this procedure cannot exclude all of the potential risks, a reasonable protective effect is expected.

A number of noteworthy correlations between ERP components and personality trait measures were found. First, P3 amplitude was negatively related to E of NEO-PI-R and BAS-FUN subscales for shorter stimulus condition. This result supported the general consensus that introverts are supposed to produce larger P3 amplitude. The distributional topographies of correlation coefficients also revealed the relationship of P3 amplitude and extraversion was conspicuous at the parietal sites. The annexed analysis presented in figure 2 describes this tendency. It was, however, intriguing that *E* of EPQ-I was not related to P3 amplitude in any gender condition. Actually, Eysenck's PEN model was developed on the base of the conceptual nervous system,

not one the solid biological foundation, so there is no assurance that the extraversion trait measured by his questionnaire is more significantly related to the biological mechanism. It does not mean that his model is not valid or incorrect; the psychometric measures on extraversion suggested by other models might be sensitive to the biological difference of the trait.

It is mentionable that correlations relating to P3 amplitudes and extraversion measures were not identified with cross-correlations of psychometric measures. In both male and female subjects, *E*; E and BAS-FUN were positively related with one another. This could imply the underlying difference of the three extraversion trait measures. For longer stimulus, only male subjects showed significant correlation relating to *E*; E and P3 amplitude. Duration of auditory stimulus might induce the interaction of gender and extraversion.

Amplitudes of the earlier ERP components were negatively related to *N* and N in females. *N*, N and N1 amplitude had negative relationships overall at sites for shorter stimulus. Conversely, P2 amplitude was positively related to *N* and N at the parietal sites in females for shorter stimulus. These salient relationships associated with *N* and N in females might manifest the difference of biological bases for emotional stability between genders. It is noticeable that *N* and N were related to earlier components; N1 and P2. If the mechanism of *N* and N is reflective of early sensory processing rather than cognitive function, it is justifiable that researchers focusing on P3 components have failed to find a remarkable relationship associated with them.

Correlation relating to *P* was found in co-gender subjects for longer stimulus. P2 amplitudes at the posterior sites (Pz, P3, and P4) were positively related to *P*. Even though most sites did not reach a reasonable α level, female subjects also produced similar distributional topography. These results could be interpreted considering the cross-correlation of psychometric measures. Correlations relating to *P* were remarkable in female subjects, and it seemed to influence co-gender analysis; male subjects did not show any significant correlation coefficients with *P*. As well as *N* and N dimension, *P* might have a biological difference between genders. Besides, *P* also was negatively related to A and C in cross correlation of psychometric measures of females; there was no consistent psychophysiological correlation to support the assimilation of A and C to *P* dimension.

Subscales of IVE also need to be interpreted at the point of the relationship between extraversion and psychoticism. As mentioned in the introduction, Eysenck rendered impulsivity from extraversion to psychoticism along with developing his theory (Eysenck & Eysenck, 1985). IVE is the questionnaire to measure the three factors of general impulsivity; Imp (Impulsivity), Ven (Venturesomeness), and Emp (Empathy) (Eysenck & Eysenck,

1978). In the cross-correlation of psychometric measures, nevertheless, only female subjects showed positive correlation between Imp and *P*. On the other hand, Ven was positively related to *E* and E in both genders; in females, Imp was also related to them. BAS was positively related to Ven in males, and Imp in females. This general tendency might imply the closer relationship between extraversion of the impulsivity trait.

In short, extraversion dimension was related to P3 amplitude, and this result supported the consensus of previous studies. On the other hand, neuroticism and psychoticism showed complex dissociation according to gender, and related to the earlier endogenous component: N1 and P2. Additionally, two types of auditory stimulus duration induced interactions between gender and personality dimensions, and affected ERP waveforms and their components.

This study suggests that ERP is a possible method to elucidate the biological bases and structures of personality models, and it would be able to contribute to this integration.

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