ISSN: 1541-745X www.idrjournal.com

©2006 IDR Publishing Ltd. Co. All rights reserved.

Individual Differences Research, Vol. 4, No. 5, pp. 292-298.

Investigating the Relationship Between Extraversion and the Auditory Brainstem Response: A Cross-validation Approach

Rhonda Swickert*
College of Charleston
Luz-Eugenia Cox-Fuenzalida & Kirby Gilliland
University of Oklahoma

**Rhonda Swickert; Department of Psychology; College of Charleston; 57 Coming St.; Charleston, SC 29424; swickertr@cofc.edu (email).*

ABSTRACT - Faster wave V latency has been found for introverts, as compared to extraverts, in studies that typically compared the ABR (auditory brainstem response) waveforms of relatively small samples of participants in the upper and lower ranges of the IE (Introversion - Extraversion) distribution. The present study confirms and extends these findings through a cross-validation approach. The IE scores of participants in the upper and lower ranges of ABR wave V latency were compared. Those who had significantly faster ABR wave V latency also had significantly lower IE scores (i.e., were more introverted) as compared to those who had slower ABR wave V latency. The correlation between wave V latency and IE score in a larger sample of participants (N = 87) was also significant (r = .22, p = .03). These results confirmed earlier findings regarding the relationship between ABR latency and IE, and are supportive of Eysenck's (1967) arousal theory of IE.

In his theory of introversion-extraversion (IE), Eysenck (1967) stated that introverts evidence greater levels of cortico-reticular activation in response to sensory stimulation than do extraverts. Furthermore, Eysenck indicated that this differential level of neural activation leads to many of the more generalized differences in social behavior and neuro-sensory performance observed between the IE personality groups. A comprehensive review by Matthews and Gilliland (1999) concluded that Eysenck's theory has remained the dominant model of IE.

One psychophysiological measure, the auditory brainstem response (ABR; see Jewett, Romano, & Williston, 1970), has been used to test Eysenck's biological theory of IE. The ABR is an auditory event-related potential measure that produces stable and replicable waveforms representing the neural activity generated along the auditory pathway during the first ten milliseconds following an auditory stimulus. The purported neural generators remain somewhat debatable, but wave I is generally viewed as initial neural activity of the acoustic nerve, wave II as either terminal acoustic nerve or cochlear nucleus activity, wave III as activity of the cochlear nucleus or superior olivary complex activity, wave IV as lateral lemniscus activity, wave V as activity of the inferior colliculus, and finally waves VI and VII probably represent medial geniculate and initial cortical projections, respectively (see reviews by Chiappa, 1990; Hall, 1992; and Hughes, 1985). Increases in CNS level of stimulation or arousal through such means as increased stimulus intensity (Stockard, Stockard, Westmoreland, & Corfits, 1979) or the administration of drugs with CNS-stimulating properties (Church & Shucard, 1987a, 1987b), have been shown to shorten latency of the ABR waveform. Thus, this pathway appears to be sensitive to factors that influence physiological arousal.

At the level of wave V, the auditory pathway is in closest proximity to the reticular formation in the brainstem (Carpenter & Sutin, 1983), the area that Eysenck (1967) hypothesized gives rise to the arousal differences between introverts and extraverts. A number of studies investigating the ABR activity of introverts and extraverts have now shown increasingly consistent findings. The absolute latency of wave V of the ABR is typically faster for introverts than for extraverts (Andress & Church, 1981; Bullock & Gilliland, 1993; Stelmack & Wilson, 1982; Swickert & Gilliland, 1998), which is consistent with Eysenck's (1967) theory of greater arousal in introverts, as compared to extraverts.

The previous studies of IE differences in ABR latency have typically been conducted by selecting relatively small samples of individuals scoring in the extreme introvert or extravert portion of the IE score distribution and comparing the average ABR waveforms of these groups. The purpose of this study is to examine the IE and ABR relationship by means of a cross validational analysis. If the positive relationship between introversion and faster ABR wave V latency is reliable, then selecting individuals for differential ABR latency and comparing their average IE score should yield like results. That is, individuals scoring in the faster ABR range should evidence more introverted scores and those with slower ABR's should display scores that are indicative of greater extraversion.

To address this hypothesis, the present study employed both distinctive and rigorous methodological procedures. First, this study began with the measurement of ABR in a large number of randomly recruited participants. Such large samples are unusual due to the financial cost and time commitment required to collect this type of data. Second, this study applied a cross-validation approach by first recording the ABR wave V latencies of this large, randomly

selected group of participants. Subsequently, extreme groups based on wave V latencies were identified, and then IE scores were compared. Finally, the ABR wave V latency was correlated with the IE scores across all participants. Because a relatively large sample of participants was included, this study provided the opportunity to examine the robustness of the relationship between ABR latency and IE across the entire range of IE scores in a fairly substantial number of participants.

Methods

Participants

The participants were recruited from a large group of students enrolled in introductory-level psychology courses who had participated in a pre-testing session during which they completed the Eysenck Personality Inventory (EPI). Participants who scored within one standard deviation above and below the mean on the EPI neuroticism dimension were then identified from those in the large, pre-tested group. This restriction was followed to help control for unusually low or high limbic system arousal influences (see H. J. Eysenck, 1967). These participants were then randomly called and screened for excessive nicotine and alcohol consumption, use of CNS-active or psychotropic medications, as well as general auditory injury or impairment. All women were also screened for premenstrual syndrome symptomatology, and those without strong evidence of such symptoms were scheduled for ABR testing during non-midcycle days of their menstrual cycle.

Participants who met these screening criteria were included in a large study which investigated the interrelationships among personality, psychophysiological activity, and performance. For the purposes of the present study, only participants' psychophysiological data were examined. The final sample in this study included 87 participants (female = 39 and males = 48). The participants in this study varied in age from 18 to 35 years.

Materials

The Eysenck Personality Inventory (EPI; Eysenck & Eysenck, 1968) was used to assess the dimensions of extraversion and neuroticism. This 57-item questionnaire includes an extraversion scale (24 items), a neuroticism scale (24 items), and a lie scale (9 items). Higher scores on the extraversion and neuroticism scales are associated with more extraverted and neurotic profiles, respectively. Eysenck and Eysenck reported that test-retest reliability over a one-year period for the extraversion scale ranged from r = .82 to .97 and for the neuroticism scale r = .84 to .88. Information concerning the validity of the EPI can be found in Eysenck and Eysenck (1968).

Procedure

The control of arousal inducing properties in the testing environment and the activities of participants prior to arriving at a testing session have been shown to be important considerations in IE research (Eysenck, 1967; Gale, 1983). Therefore, the present study was designed in part to provide a period of approximately one hour prior to psychophysiological testing during which the participants' activities could be controlled with regard to stimulation level, as well as controlling such factors as food, nicotine, and caffeine consumption.

When participants arrived at the laboratory, they were first taken to a workstation for assessing human performance tasks. They were provided a general explanation of the study and its testing phases, given consent forms, and given oral instructions for some simple, computerized human performance tasks (e.g., low workload levels of psychomotor tracking/ Sternberg memory tasks). During the hour preceding ABR testing, each participant performed the simple human performance tasks at a self-paced, relatively low-demand level, completed some questionnaires (including a re-test on the EPI), and were then administered a method-of-limits auditory screening test to insure the integrity of each participant's hearing ability. This provided a clearly defined, well-controlled period of moderate activity level for all participants prior to ABR testing.

Consistent with standard ABR measurement practice (see Hall, 1992), participants were then instrumented with standard, 10mm gold EEG electrodes placed at Cz, A1, A2, and Fpz (refer to the 10-20 International System of electrode placement; Jasper, 1958). Participants were seated within an acoustically and electrically shielded booth in a supine position with their head and neck supported to reduce muscle artifact.

Recording of ABRs was conducted with a Biologic clinical averager. Waveforms were averaged over 2048 trials using 70 dB HL 0.1 msec condensation clicks at a rate of 11.1 clicks per second. The sampling epoch was 10 msec. Clicks were presented simultaneously to both the left and right ear (i.e., binaural recording).

Following ABR testing, participants had electrodes removed and were debriefed. All testing was conducted between 9:00 a.m. and 4:00 p.m. to control for diurnal variation in both ABR and IE performance (see Marshall & Donchin, 1981; Revelle, Humphreys, Simon, & Gilliland, 1980).

Results and Discussion

To address the primary hypothesis of the study, extreme ABR latency groups were defined first by identifying those individuals who scored in the upper and lower 27% of the ABR wave V latency distribution (see Cox, 1957, for a discussion of this procedure). Using this criterion, individuals scoring below 5.63 msec were considered fast responders and those who scored above 6.04

msec were considered slow responders. In order to control for the effect of gender, an Analysis of Covariance (ANCOVA) procedure was used to analyze the data. However, because the univariate *F* test does not allow for a directional (one-tailed) test, the resulting *F* statistic was converted to a *t* statistic to determine the appropriate p-value[1]. Findings indicated that the fast ABR responders had significantly lower extraversion scores (i.e., were more introverted) than the slow ABR responders (t (44) = 1.75, p = .04). The mean extraversion score for the fast ABR responders was 11.33 (SD = 3.35), while for the slow ABR responders it was 13.23 (SD = 5.19).

This study also provided the opportunity to conduct a correlation analysis to determine the relationship between ABR wave V absolute latency and IE scores across a large sample of participants. The correlation between ABR wave V absolute latency and IE scores was r = .22, p = .03. This significant correlation is consistent with previous studies (Andress & Church, 1981; Bullock & Gilliland, 1993) that demonstrated shorter wave V latency for introverts, as compared to extraverts.

In sum, this study was designed to examine the robustness of the relationship between IE and ABR latencies, using a distinctive methodological approach. As predicted, the results of this study confirmed that those with faster ABR latencies evidence more introverted scores and those with slower ABR latencies evidence more extraverted scores. Furthermore, this study demonstrated the robustness of this relationship across a much wider range of IE scores than past extreme score research has provided. These findings show that the portion of the ABR reflecting neural activity closest to the ARAS, the area of the brain Eysenck suggested gives rise to differential arousal across the IE continuum, is significantly associated with extraversion scores. As a result, introverts appear to conduct activity more quickly in this area of the brain than do extraverts. The results of this study are supportive of past ABR work testing Eysenck's biologically-based theory of extraversion and broaden these findings to a more robust measure of the auditory system.

Footnote

1. As Hays (1988) has noted, when the *F* test has a numerator degrees of freedom of 1, then the square root of the *F* statistic is functionally equivalent to the *t* statistic ($t_{(v)} = \sqrt{F_{(1, v2)}}$; $v = v2$).

Author Note

The authors appreciate the support of Dr. Judy Lauter who loaned equipment and generously provided support during the data collection phase of this investigation. We also would like to thank Dr. James Hittner for his comments and helpful assistance with the statistical analyses conducted in this paper.

References

Andress, D., & Church, M. (1981). Differences in brainstem auditory evoked responses between introverts and extraverts as a function of stimulus intensity. *Psychophysiology, 18*, 156-163.

Bullock, W. A., & Gilliland, K. (1993). Eysenck's arousal theory of introversion-extraversion: A converging measures investigation. *Journal of Personality and Social Psychology, 64*, 113-123.

Carpenter, M. B., & Sutin, J. (1983). *Human neuroanatomy* (8th ed.). Baltimore, Maryland: Williams & Wilkins.

Chiappa, K. H. (1990). *Evoked potentials in clinical medicine.* (2nd ed.). New York: Raven Press.

Church, M. W., & Shucard, D. W. (1987a). Theophylline-induced changes in the mouse brainstem auditory evoked potential. *Neurotoxicology and Teratology, 9*, 59-66.

Church, M. W., & Shucard, D. W. (1987b). Pentobarbital-induced changes in the mouse brainstem auditory evoked potential as a function of click repetition rate and time postdrug. *Brain Research, 403*, 72-81.

Cox, D. (1957). Note on grouping. *Journal of the American Statistical Association, 52*, 543-547.

Eysenck, H. J. (1967). *The biological bases of personality*. Springfield, Illinois: Thomas.

Eysenck, H. J., & Eysenck, S. (1968). *The Eysenck Personality Inventory manual.* San Diego: Educational and Industrial Testing Service.

Gale, A. (1983). Electroencephalographic studies of extraversion-introversion: A case study in the psychophysiology of individual differences. *Personality and Individual Differences, 4*, 429-435.

Hall, J. W. III (1992). *Handbook of auditory evoked responses*. Boston, Massachusetts: Allyn and Bacon.

Hays, W. (1988). *Statistics for psychologists* (3rd ed). New York: Holt, Rinehart & Winston.

Hughes, J. R. (1985). A review of the auditory system and its evoked potentials. *American Journal of EEG Technology, 25*, 115-158.

Jasper, H. H. (1958). The ten-twenty electrode system of the International Federation. *Electroencephalography and Clinical Neurophysiology, 10*, 371-375.

Jewett, D. L., Romano, M. N., & Williston, J. S. (1970). Human auditory evoked potentials: Possible brainstem components detected on the scalp. *Science, 167*, 1517-1518.

Marshall, N. K., & Donchin, E. (1981). Circadian variation in the latency of brainstem responses: Its relationship to body temperature. *Science, 212*, 356-358.

Matthews, G., & Gilliland, K. (1999). The personality theories of H. J. Eysenck and J. A. Gray: A comparative review. *Personality and Individual Differences, 26,* 583-626.

Revelle, W., Humphreys, M. S., Simon, L., & Gilliland, K. (1980). The interactive effect of personality, time of day, and caffeine: A test of the arousal model. *Journal of Experimental Psychology: General, 109,* 1-31.

Stelmack, R. M., & Wilson, K. G. (1982). Extraversion and the effects of frequency and intensity of the auditory brainstem evoked response. *Personality and Individual Differences, 3,* 373-380.

Stockard, J. J., Stockard, J. E., Westmoreland, B. F., & Corfits, J. L. (1979). Brainstem auditory-evoked responses: Normal variation as a function of stimulus and subject characteristics. *Archives of Neurology, 36,* 823-831.

Swickert, R J., & Gilliland, K. (1998). Relationship between the brainstem auditory evoked response and extraversion, impulsivity, and sociability. *Journal of Research in Personality, 32,* 314-330.