



## IMPULSIVENESS, AGGRESSION, READING, AND THE P300 OF THE EVENT-RELATED POTENTIAL

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**Summary**—In the present research, attentional impulsiveness and non-planning impulsiveness were found to relate positively with physical aggression, negatively with reading level, and negatively with the amplitude of the parietal-region P300 of the event-related potential evoked in an oddball and continuous performance task (CPT). In contrast, motor impulsiveness was found not to relate to aggression or reading level, but, interestingly, it was found to relate positively to amplitude of the parietal-region P300 in the oddball task. Additionally, physical and verbal aggression related negatively to reading level, whereas anger and hostility did not. Physical and verbal aggression also related negatively to the amplitude of the central- and parietal-region P300s in the oddball task but not in the CPT. Moreover, hostility related negatively to the amplitude of the central-region P300 in the CPT, but did not relate significantly to the P300 amplitude in the oddball task. Anger showed no significant relations with the amplitude of the P300 in any region or task. In addition to reading level relating negatively with these subtraits of impulsiveness and aggression, it related positively with the amplitude of P300. These results are discussed in terms of Eysenck's theory of impulsiveness. © 1997 Elsevier Science Ltd. All rights reserved.

### INTRODUCTION

Previous research has demonstrated negative relationships between reading levels and impulsiveness, positive relationships between reading levels and the amplitude of the P300 component of the event-related potential recorded from the scalp, and negative relationships between impulsiveness and the amplitude of the P300 (e.g. Barratt, Stanford, Kent & Felthous, in press). Understanding these relationships is important because impulsiveness and verbal deficits relate to anti-social behavior (e.g. Eysenck & Gudjonsson, 1989; Lynam, Moffitt & Stouthamer-Loeber, 1993; Prentice & Kelly, 1963; West & Farrington, 1973; White, Moffitt, Caspi, Bartusch, Needles & Stouthamer-Loeber, 1994). In the present study, we examined relationships among these variables in an effort to better understand them.

Event-related brain potentials (ERPs), a non-invasive measure of neural activity related to sensory and cognitive information processing, have been used to assist in providing an understanding of dyslexia (Duncan, Rumsey, Wilkniss, Denckla, Hamburger & Odou-Potkin, 1994; Taylor & Keenan, 1990), attention-deficit hyperactivity disorder (ADHD; Klorman, Brumaghim, Salzman, Strauss, Borgstedt, McBride & Loeb, 1988), and impulsive and premeditated aggression (Barratt *et al.*, in press). The P300, an endogenous component of the ERP that measures cognitive processing, has been used successfully in much of this previous research. This research has shown that individuals who have dyslexia, ADHD, and impulsive aggression are more likely to have smaller amplitude P300s. These effects have emerged presumably because the reduced amplitude of the P300 reflects a reduction in attentional resources available for information processing, because these resources are not allocated effectively (Hoffman, 1990; Wickens, 1984), or because of decreased physiological arousal (Polich & Kok, 1995).

The negative relationship between impulsiveness and the amplitude of the P300 can be explained by Eysenck's (1993) theory of impulsiveness. According to Eysenck, impulsivity is due to low cortical arousal, and this low cortical arousal relates to poor functioning of the reticular activating system. With increased cortical arousal, activity in lower brain structures is inhibited, thus decreasing the probability of impulsive behaviors. In contrast, with decreased cortical arousal, activity in lower

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brain structures is disinhibited, thus enhancing the probability of impulsive behaviors. These ideas are supported by findings that indicate that impulsiveness is related to psychoticism and extraversion, and that psychoticism and extraversion are related to lower cortical arousal (Strelau & Eysenck, 1987). Additional findings supporting this idea are the effects of stimulant drugs decreasing impulsiveness (Eysenck, 1963; Eysenck & Gudjonsson, 1989) and increasing the amplitude of P300 (Klorman *et al.*, 1988). The negative relation between reading level and impulsiveness could be similarly be explained in terms of Eysenck's theory. That is, one could posit that lower cortical arousal causes poorer reading levels.

### *The present study*

Thus, in the present study, we sought to assess the relationships between impulsiveness, aggression, reading level, and P300 evoked in two separate tasks. Few studies have assessed relationships between P300 and aggression. Moreover, very few studies have assessed this relationship in adolescents, and no studies have assessed it using both an oddball-type task and a continuous performance task (CPT). Thus, in the present study, we sought to extend this previous research by examining P300/aggression relations in adolescents, using two tasks designed to elicit the P300—an oddball task and a continuous performance task. Moreover, we also assessed the relations between these two variables and reading level and impulsiveness. Assessing all of the variables within one study allowed us to examine and thus contribute to an understanding of their interrelations.

We also attempted a more fine grained analysis of the interrelations among these variables by examining the subtraits of impulsiveness and aggression, both reading accuracy and reading comprehension, and the amplitude of the P300 in the mid-frontal, mid-central, and mid-parietal regions during an oddball-type task and a CPT. Our endeavour to examine the subtraits of impulsiveness and aggression was possible because of recent, large-scale, factor-analytic studies that have shown impulsiveness to be composed of three second-order factors, labeled attentional, motor, and non-planning impulsiveness (Patton, Stanford & Barratt, 1995), and aggression to be composed of four factors, labeled physical aggression, verbal aggression, anger, and hostility (Buss & Perry, 1992).

## METHOD

### *Participants*

Participants were 20 boys and 14 girls between the ages of 11 and 17 ( $M = 12.91$ ) selected from an adolescent psychiatric in-patient unit at the University of Texas Medical Branch at Galveston ( $N = 9$ ) or one of two middle schools located in Galveston, Texas ( $N = 25$ ). They and their primary caretakers volunteered them to participate, and they received no compensation for participation. The racial composition of the sample was 12 Blacks, 10 Hispanics, 11 Whites, and 1 Asian.

### *Procedure*

The session began at 9:00 a.m. Life history was assessed first. Participants were then prepared for the recording of an electroencephalogram (EEG). Participants performed an oddball-type task followed by two CPTs. A 45-min break was then taken for lunch. Participants were then administered eight subscales of the Wechsler Intelligence Scale for Children-III (Wechsler, 1991), the Gray Oral Reading Test (Wiederholt & Bryant, 1992), the Barratt Impulsiveness Scale (BIS-11; Patton *et al.*, 1995), Buss and Perry's (1992) aggression questionnaire, and other measures not relevant to the purposes of present research.

### *Psychophysiological recording*

For the recording of the EEG, participants were seated in a comfortable chair in a dimly-lit room. They wore stereo headphones that emitted continuous white noise (in the 45–60 dB range) that masked extraneous sounds. EEG activity was recorded monopolarly using tin electrodes that were in a stretch-lycra cap (Electrocap). EEG activity was recorded from 29 scalp sites. All sites were referenced on-line to linked ear lobes. All electrode impedances were less than 5 K ohms. A Nihon Koden Electroencephalograph Model 4221 amplified signals by a factor of 20,000 (bandpass 0.026–

35 Hz). The EEG was digitized continuously at 512 Hz. Digitized data were subsequently analyzed off-line. Data were digitally filtered using a low-pass filter with a half-amplitude frequency of 12.5 Hz (96 dB/octave rolloff). Data were corrected for blink artifact using the method of Semlitsch, Anderer, Schuster and Presslich (1986). Data were partitioned into epochs beginning 100 msec prior to stimulus onset and ending 900 msec after stimulus onset. Data were then averaged by type (target, non-target); only stimuli that were responded to correctly were included in the averages.

Peak amplitudes were calculated by subtracting the average voltage in the 100 msec prior to stimulus onset from the peak voltage in the specified latency ranges. Latencies were measured from stimulus onset. Only data from participants who had at least 20 ERPs that occurred on trials that were responded to correctly were used in the analyses of the ERP data. Only amplitudes of the P300 component will be reported in the present report, because the latencies of the P300 did not correlate significantly with any of the measures of interest. In addition, only results from Pz, Cz, and Fz will be reported in the present article.

*Oddball task.* For the oddball task, ERPs were elicited with 150 visual stimuli presented on a computer monitor. A 1000 Hz tone 1 sec in duration preceded the presentation of each visual stimulus. Each visual stimulus was presented for 1 sec, with a stimulus onset asynchrony (SOA) of 5 sec. The target stimulus was a white 'B' (1.3 cm high  $\times$  1.5 cm wide) and the non-target stimulus was a white 'A' (same size as the target). Stimuli were viewed from a distance of approximately 55 cm. Target stimuli occurred with a probability of 0.20, and non-target stimuli occurred with a probability of 0.80. Participants were told to focus on the plus sign that was continuously present in the center of the computer monitor because the stimuli would be presented there. They were also told to press a key pad with their left forefinger when 'B' appeared and with their right forefinger when 'A' appeared. Response times, hits, and misses were recorded. This task has been used successfully in previous research examining dyslexia and impulsive aggression (Barratt *et al.*, in press).

*Continuous performance task.* For the CPT, ERPs were elicited with 300 visual stimuli presented on a computer monitor. Each stimulus was presented for 50 msec, with an SOA of 1.5 sec. The stimuli were white letters (1.3 cm high  $\times$  1.5 cm wide). Stimuli were viewed from a distance of approximately 55 cm. Each of eight letters (B, D, K, N, S, T, W, and X) was displayed with equal probability and in an unpredictable order. The target stimulus was defined as the occurrence of any letter that was identical to the preceding one. There were 40 targets. Participants were told to focus on the plus sign that was continuously present in the center of the computer monitor because the stimuli would be presented there. They were also told to press the key pad with their right forefinger when they saw a letter that was identical to the preceding one. Participants practiced the task with coaching from the experimenter until they made five consecutive correct detections, and they were encouraged to emphasize accuracy over speed. Response times and hits and misses were recorded. Similar tasks have been used successfully in previous research examining ADHD (e.g. Klorman *et al.*, 1988).

#### *Assessments*

Participants were administered the following assessments. Subscales of the Wechsler Intelligence Scale for Children-III (Wechsler, 1991) were administered to assess verbal intelligence (IQ) and performance IQ. To assess verbal IQ, the following tests were administered: Similarities, Arithmetic, Vocabulary, Comprehension, and Digit Span. To assess performance IQ, the following tests were administered: Picture Arrangement, Block Design, and Coding. Prorated IQs were computed from these subscales.

The Gray Oral Reading Test (Wiederholt & Bryant, 1992) was administered to assess oral reading rate, accuracy, and comprehension. In this test, the participant reads essays aloud, and the examiner records errors (mispronunciations, insertions, omissions) and reading time for each essay to assess reading accuracy. After reading each essay, the participant is asked multiple-choice questions about the essay to assess comprehension. Reading level was determined by subtracting the grade level the student should be in from the grade level obtained on GORT-3 accuracy and comprehension. Thus, higher scores on this index reflect higher reading levels.

The Barratt Impulsiveness Scale (BIS-11; Patton *et al.*, 1995), a self-report questionnaire, was administered to assess impulsiveness. It is composed of three second-order factors: (i) motor impul-

siveness, which is characterized by acting without thinking; (ii) non-planning impulsiveness, which is characterized as a present orientation or a lack of planning for the future; and (iii) attentional impulsiveness, which is characterized by having difficulty maintaining attention or concentrating.

The Buss and Perry (1992) Aggression Scale, a self-report questionnaire, was administered to assess level of aggression. It is composed of four factors: (i) physical aggression, which assesses the frequency of acting aggressively; (ii) verbal aggression, which assesses the frequency of behaving verbally aggressively; (iii) anger, which assesses the emotional component of aggression; and (iv) hostility, which assesses the cognitive component of aggression that can be described as "feelings of ill will and injustice" (Buss & Perry, 1992, p.457).

All self-report questionnaires were read aloud to the participants by the experimenter, so that participants with difficulties with reading would be able to better understand the questions. Participants were asked to indicate if they needed assistance in understanding the meaning of questions. Participants gave their responses to the questions aloud to the experimenter, who recorded responses.

## RESULTS

### *Impulsiveness*

As in previous research (Barratt *et al.*, in press), impulsiveness (as measured by the full scale score for the BIS-11) correlated negatively with reading accuracy ( $-0.32$ ). In addition, impulsiveness correlated negatively with reading comprehension ( $-0.33$ ). To better understand these relationships, we investigated the relations between reading level and the BIS-11 subscales, a strategy not employed in the previous research. As shown in Table 1, these impulsiveness-reading relationships were negative and significant for the attention subscale and the non-planning subscale. In contrast, the motor subscale did not correlate significantly with accuracy and comprehension. These relationships suggest that low levels of reading are associated with high levels of impulsiveness, especially high levels of attentional impulsiveness and non-planning impulsiveness.

In addition, physical aggression related positively to impulsiveness, especially attentional and non-planning impulsiveness. Verbal aggression, anger, and hostility did not relate significantly to impulsiveness.

All impulsiveness subtraits related negatively to both verbal and performance IQ, although these relations were most pronounced for the non-planning subtrait.

As in previous research (Barratt *et al.*, in press), the amplitude of the P300 related negatively to impulsiveness. These relations tended to be more pronounced in the parietal region than in the central and frontal regions, and they were significant for the relation between attentional and non-planning impulsiveness and P300 amplitude in the parietal region.

Only one of the behavioral measures collected during the performance of the oddball task and CPT correlated significantly with impulsiveness. Percent of false alarms correlated positively with motor impulsiveness, suggesting that high levels of motor impulsiveness were related to high levels of false alarms during the oddball task.

### *Aggression*

As mentioned above, physical aggression, but not verbal aggression, anger, and hostility, correlated positively with impulsiveness. In addition, physical and verbal aggression correlated negatively with reading accuracy and comprehension, whereas anger and hostility did not. Physical and verbal aggression also correlated negatively with intelligence levels, whereas anger and hostility did not. These relationships suggest that high levels of physical and verbal aggression are associated with low levels of reading accuracy and comprehension and low levels of intelligence.

Significant negative relationships emerged between physical and verbal aggression and the amplitude of the central- and parietal-region P300s during the oddball task; these relations were not significant for anger and hostility. These relationships suggest that high levels of physical and verbal aggression are associated with low amplitude P300s during an oddball task. In addition, hostility correlated negatively with the amplitude of the central-region P300 during the CPT; no other aggression/P300 relationships were significant.

Table 1.

	Att	Mot	NP	PA	VA	Ang	Hos	RA	RC	VIQ	PIQ	OFz	OCz	OPz	Olat	Olat	Olat	OFz	OCz	CPz	CCz	CPz	Chit	Clat
1. BIS-Attn	0.44**																							
2. BIS-Mot	0.47**	0.40*																						
3. BIS-NP	0.43**	0.21	0.39*																					
4. Physical agg	0.09	-0.02	0.22	0.47**																				
5. Verbal agg	0.14	0.17	0.26	0.71**	0.50**																			
6. Anger	0.23	0.15	0.25	0.21	-0.11	0.06																		
7. Hostility	-0.42**	-0.22	-0.44**	-0.24	-0.42**	-0.8	-0.01																	
8. Read accuracy	-0.43**	-0.25	-0.38*	-0.40*	-0.50**	-0.27	-0.26	0.77**																
9. Read comp	-0.33	-0.25	-0.42**	-0.36*	-0.43**	-0.15	-0.21	0.56**	0.81**															
10. VIQ	-0.29	-0.37*	-0.43**	-0.39*	-0.48**	-0.24	-0.07	0.79**	0.64**	0.79**														
11. PIQ	-0.10	0.01	-0.34	-0.31	-0.22	-0.36	-0.28	0.09	0.15	0.07	0.28													
12. Od Fz amp	-0.24	0.21	-0.34	-0.50**	-0.55**	-0.35	-0.20	0.21	0.33	0.26	0.38*	0.71**												
13. Od Cz amp	-0.25	0.35	-0.37	-0.48**	-0.54**	-0.23	-0.13	0.42*	0.44*	0.35	0.41*	0.10	0.85**											
14. Od Pz amp	-0.01	-0.37	-0.06	-0.24	-0.42**	-0.25	0.07	0.10	0.24	0.10	0.20	-0.32	-0.19	-0.16	-0.30									
15. Od hit	-0.12	-0.01	-0.07	0.09	0.00	0.01	-0.18	0.29	0.28	0.21	-0.34	0.08	0.36	0.38*	-0.41*	-0.08								
16. Od latency	0.30	0.64**	0.25	0.18	0.02	0.02	0.47**	-0.10	-0.14	-0.21	-0.07	0.19	0.29	0.30	0.18	-0.39*	-0.09							
17. Od false alarm	-0.24	-0.22	-0.31	-0.31	0.00	-0.28	-0.22	-0.12	-0.06	-0.07	-0.07	0.20	0.49**	0.37	0.16	-0.14	-0.19	0.52**						
18. CPT Fz amp	-0.19	-0.04	-0.29	-0.19	-0.08	-0.29	-0.42*	-0.05	0.08	0.08	0.12	0.20	0.54**	0.48**	0.04	0.09	0.12	0.17	0.73**					
19. CPT Cz amp	-0.46**	0.00	-0.43*	-0.06	-0.13	-0.13	-0.31	0.27	0.35	0.26	0.32	0.34	0.54**	0.48**	0.02	-0.08	-0.18	-0.01	-0.11	-0.21				
20. CPT Pz amp	0.07	-0.12	-0.04	-0.06	0.09	-0.01	-0.24	0.04	0.10	0.24	0.18	0.30	0.16	-0.03	0.02	-0.08	0.14	-0.19	0.24	0.52**	0.06			
21. CPT hit	-0.26	0.02	-0.12	0.09	-0.11	0.26	-0.07	0.43**	0.47**	0.41*	0.17	-0.16	0.04	0.12	-0.23	0.54**	0.23	-0.10	-0.01	-0.05	-0.19	-0.28		
22. CPT latency	0.03	0.10	0.08	-0.11	0.11	-0.19	0.02	-0.25	-0.42*	-0.42*	-0.29	-0.35	-0.03	-0.17	-0.23	0.28	0.23	-0.10	-0.01	-0.05	-0.19	-0.28		
23. CPT false alarm	Att	Mot	NP	PA	VA	Ang	Hos	RA	RC	VIQ	PIQ	OFz	OCz	OPz	Olat	Olat	Olat	OFz	OCz	CPz	CCz	CPz	Chit	Clat

Note: For correlations involving the oddball data,  $N = 25$ ; for CPT,  $N = 27$ . For all correlations, \* indicates  $P < 0.05$  and \*\* indicates  $P < 0.02$ . Att = attentional impulsiveness. Mot = motor impulsiveness. NP = non-planning impulsiveness. PA = physical aggression. VA = verbal aggression. Ang = anger. Hos = hostility. RA = reading accuracy. RC = reading comprehension. VIQ = verbal intelligence. PIQ = performance intelligence. OFz = amplitude of P300 for Fz in oddball task. OCz = amplitude of P300 for Cz in oddball task. OPz = amplitude of P300 for Pz in oddball task. Olat = percentage of correct responses to infrequent stimuli in oddball task. Olat = latency to respond to infrequent stimuli target in oddball task. Ofa = percentage of false alarms, responding to frequent stimuli as though they were infrequent. CPT = percentage of false alarms in CPT, responding to non-target stimuli as though they were target stimuli. Cfa = percentage of false alarms in CPT, responding to non-target stimuli as though they were target stimuli.

