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Hostile attribution biases for relationally provocative situations and event-related potentials ☆

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ABSTRACT

This exploratory study investigates how hostile attribution biases for relationally provocative situations may be related to neurocognitive processing using the P300 event-related potential. Participants were 112 (45 women) emerging adults enrolled in a large, public university in upstate New York. Participants completed self-report measures on relational aggression and hostile attribution biases and performed an auditory perseveration task to elicit the P300. It was found that hostile attribution biases for relational provocation situations was associated with a larger P300 amplitude above and beyond the role of hostile attribution biases for instrumental situations, relational aggression, and gender. Larger P300 amplitude is interpreted to reflect greater allocation of cognitive resources or enhanced "attending" to salient stimuli. Implications for methodological approaches to studying aggression and hostile attribution biases and for theory are discussed, as well as implications for the fields of developmental psychology and psychopathology.

1. Introduction

Attributions in social events allow individuals to make judgments regarding the motivations of others and provide the individual with information regarding how he or she should react (Crick and Dodge, 1994). Some individuals tend to interpret social interactions in a negative manner and exhibit social cognitions known as hostile attribution biases. Hostile attribution biases may be operationally defined as over-attributing hostile intent to peers' behaviors, even in situations where hostile attribution is not warranted, such as when the actual intent is benign in nature or the situation is ambiguous (Dodge, 1980; Dodge and Frame, 1982; Dodge et al., 1984). Further, hostile attribution biases seem to be indicative of encoding social information and reactively or impulsively responding aggressively to cues in situations of high arousal (Crick and Dodge, 1996; Dodge and Coie, 1987; Schwartz et al., 1998).

An influential model has been developed that provides a hypothesized structure to the processing conducted in social situations. The social information processing (SIP) model of children's adjustment provides a conceptual framework for how aggressive children perceive, interpret, and make decisions about social stimuli and situations in ways that increase their likelihood of engaging in aggressive behavior in the future (Crick and Dodge, 1994, 1996). In this model, behavioral responses to social situations are based on a set of processing steps that are believed to be outside of consciousness (Crick and Dodge, 1994; Quiggle et al., 1992). The steps include: 1) encoding of cues, 2) interpretation of cues, 3) clarification of goals, 4) response access or construction, 5) response decision, and 6) behavioral enactment (Crick and Dodge, 1994). Hostile attribution biases or interpreting hostility in ambiguous provocation situations occur at the second step of this model following the interpretation processing step.

1.1. Hostile attribution biases: past research

The majority of the research on hostile attribution biases has focused on instrumental provocation situations based on physical aggression, or the intent to hurt another individual using physical force or the threat of physical harm (Dodge et al., 2006; Orobio de Castro et al., 2002). This research has found that hostile attribution biases are related to social maladjustment and externalizing disorders (e.g., Crick and Dodge, 1994; Crick et al., 2002; Dodge and Frame, 1982; Dodge and Somberg, 1987; Fontaine et al., 2002; Frick et al., 2003). More specifically, hostile attribution biases for instrumental situations have been associated with being considered physically aggressive (Dodge, 1980; Dodge and Somberg, 1987). Intent attribution biases often precede an aggressive response (Dodge and Frame, 1982) or predict the later development of aggressive behavior (Dodge

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et al., 1990). However, given the lack of research with girls, it is difficult to conclude whether the associations between physical aggression and hostile intent attributions and subsequent interpersonal and processing issues occur for girls as well (Orobio de Castro et al., 2002).

The past emphasis on instrumental scenarios and focus on physical aggression has offered many important contributions to the understanding of social information processing and aggression; however, it does not include other developmentally salient situations and scenarios that may be more relevant for the display of relationally aggressive behaviors (Crick, 1995). Relational aggression is defined as the removal or the threat of the removal of relationships as the means of harm and can be exhibited through a wide variety of overt and covert behaviors, such as gossip, the "silent treatment," and exclusion (Crick and Grotpeter, 1995). There is limited research on hostile attribution biases for relational provocations (Bailey and Ostrov, 2008; Crain et al., 2005; Crick, 1995; Crick et al., 2002; Yeung and Leadbeater, 2007). In research done by Crick and colleagues (Crick, 1995; Crick et al., 2002), ambiguous relationship conflicts are used to investigate underlying hostile interpretation of cues concerning social relationships. Such conflicts consist of situations such as social exclusion and manipulation (e.g., not having received an invitation for a party that the character overhears other children talking about; Crick, 1995). Crick (1995) demonstrated that relationally aggressive children report that relationship conflict provocations are distressing, problematic, and motivated by hostile intent. However, this relation has not been consistently found (Crain et al., 2005).

There are several limitations in the extant literature. The SIP model posits that a database comprised of various cognitive processes (e.g., memory, social knowledge, social schemas, and attention) that interface with each step of processing and that in turn our processing and behaviors influence the database. However, to date no known research has attempted to understand associations between social cognitions or behavior and this "black box" or vice versa. Second, as discussed, there is limited research focused specifically on relational aggression and social information processing (Crick, 1995; Crick et al., 2002; Crick and Werner, 1998; Crain et al., 2005; Yeung and Leadbeater, 2007). Therefore, we have a limited understanding of biased processing of social information related to relationships. Finally, the majority of research investigating hostile attribution biases for relational provocations has studied this construct in middle childhood (i.e., approximately ages six to eleven-years-old; Crain et al., 2005; Crick, 1995; Crick et al., 2002; Yeung and Leadbeater, 2007). Bailey and Ostrov (2008) extended the research on hostile attribution biases for relational provocations to emerging adulthood, or the developmental period between adolescence and young adulthood (i.e., approximately ages 18 to 25; Arnett, 2000). With increased sanctions for physical aggression and corresponding salience of relational aggression during this developmental period (Loudin et al., 2003; Werner and Crick, 1999), we believe this is an important period for further study of both aggressive behavior and associated social cognitions.

1.2. Understanding underlying neurophysiological processes

Overall, there has been limited research into the role of social information processing and hostile attribution biases for relational provocation situations despite the promise that this area of investigation appears to hold. Elucidating cognitive processing associated with relationally aggressive behavior and distress caused by relationship conflict may help to inform intervention and prevention efforts. Relational aggression has been theoretically considered to be associated with maladaptive outcomes (Crick and Zahn-Waxler, 2003) and has been demonstrated to be empirically associated with psychopathology (i.e., internalizing and externalizing problems; Prinstein et al., 2001), as well as social and emotional difficulties (i.e., relationship problems; Goldstein and Tisak, 2004; Linder et al., 2002; Loudin et al., 2003). Therefore, understanding cognitive processes associated with hostile attribution biases and aggression may be important for understanding different developmental pathways or trajectories towards psychopathology and maladaptive outcomes.

Investigations of neural mechanisms may provide important information regarding aggressive behavior and social information processing. Various steps of the SIP model could be associated with neural mechanisms and help to account for the automatic nature of social information processing. In order to conduct such explorations into associated neural mechanisms, several studies exploring mechanisms associated with physical aggression have utilized event-related brain potentials (ERP). ERPs allow the investigation of electrocortical activity linked with a specific external or internal cognitive event (Fabiani et al., 2000; Mathias and Stanford, 1999) and the investigation of the neural underpinnings of cognition (Polich, 2007). The P300 component of the ERP has been used to assess brain functioning related to information processing (Hillyard and Kutas, 1983) as well as attentional and memory processes (Polich, 1998). More specifically, it has been suggested that P300 amplitude is related to the allocation of and efficiency in cognitive processing and neural attention resources (Hillyard and Kutas, 1983; Polich, 1998, 2007). Lower amplitude, for example, has been associated with less efficient cognitive functioning (Hillyard and Kutas, 1983; Polich, 1998). Furthermore, the latency of the P300 is suggested to represent stimulus evaluation time and is thought to be responsive to the level of task processing (Hillyard and Kutas, 1983; McCarthy and Donchin, 1981; Polich, 2007).

Several studies have demonstrated interesting differences in P300 amplitude and latency between those categorized as high in functions of physical aggression (i.e., reactive and proactive) and control groups. There appears to be important evidence of neurocognitive impairment associated with aggressive and hostile samples (Barratt et al., 1997; Bond and Surguy, 2000; Gerstle, Mathias, and Stanford, 1998; Houston et al., 2003; Mathias and Stanford, 1999; New et al., 2002; Raine et al., 1998). For example, adults categorized as impulsive aggressive (i.e., reactively aggressive), but not adults categorized as proactively aggressive (i.e., premeditated) or non-aggressive, have been found to have reduced P300 amplitude (Barratt et al., 1997; Gerstle, et al., 1998; Mathias and Stanford, 1999) and increased P300 latency (Mathias and Stanford, 1999). Within the hostility literature, similar findings have been reported. For example, attitudinal hostility has been associated with prolonged P300 latency (Bond and Surguy, 2000) and reduced P300 amplitude (Harmon-Jones et al., 1997). In summary, neurophysiological studies have demonstrated differences in the neural function of those who are more reactively aggressive or prone to hostility. Such findings as reduced P300 amplitude and increased P300 latency as related to aggressive and hostile behavior could suggest impulse control and frontal brain functioning detriments. However, there has been no apparent research to date investigating relational aggression, stimulus processing, and the allocation of cognitive attention resources.

In the present study, the P300 was elicited by an auditory perseveration (AP) Task designed to assess cognitive set-shifting (i.e., response regulation) that is thought to be mediated by the frontal lobe (Bauer and Hesselbrock, 2003; Lezak et al., 2004). Prior studies have demonstrated reduced P300 amplitude in response to the set-shifting signal stimulus in this task in samples characterized with conduct disorder (Bauer and Hesselbrock, 2003) and impulsive aggression Schlienz et al., 2005). Thus, for the current study this task was chosen over more generalized measures of the P300, such as a standard oddball task (Fabiani et al., 2000; Mathias and Stanford, 1999), due to its hypothetical relation to frontal lobe functioning, which has long been associated with behavioral regulation (Lezak et al., 2004).

1.3. Present study

This exploratory study investigates how hostile attribution biases for relationally provocative situations may be related to the P300 ERP and, more generally, frontal lobe functioning as it relates to the social-cognitive process of intent attributions. As brain development, particularly the frontal lobe, does not fully mature until early adulthood, emerging adulthood is a developmental period of considerable interest with respect to neurocognition and its role in socialization (Arnett, 2000). Furthermore, previous research has implicated differences in frontal brain function with the manifestation of hostile cognition and aggressive behavior (i.e., Bond and Surguy, 2000; Mathias and Stanford, 1999). As we are interested primarily in the associations with hostile attribution biases, which are based on interpretations and responses in the moment, and the associations between cognitive processes as well as neural processes and these interpretations, we will be considering hostile attribution biases and aggression to be predictive of P300 variables. Given this research, we expect that hostile attribution biases for relational provocations may be associated with longer latency and lower amplitude, as has been demonstrated in the physical aggression ERP research. Although we anticipate that these results may be similar to the physical aggression literature, we do not have specific hypotheses. This study serves as an important first step to looking at the associations between the basic forms of aggression (i.e., relational and physical) and underlying social cognition variables via the P300. In addition, we will also explore the behavioral responses to the set-shifting prompts and investigate the role of hostile attribution biases for relational provocations and aggression in predicting perseverative responding, or the inability to shift responding when required to do so by task instructions. Given the relative lack of research on the AP task, this aspect of the study is purely exploratory.

Given the potential gender differences between the salience of interpersonal conflict (Crick et al., 2002; Rose and Rudolph, 2006; Rudolph et al., 2000), the effect of gender will also be explored. To test these hypotheses, we conducted a multi-method (i.e., self-report and ERP) study with emerging adults.

2. Methods

2.1. Participants

Participants were 112 (67 male and 45 female) college students enrolled in a large, public university in the northeast. The participants ranged in age from 18 to 24 years ($M=19.34$ years; SD = 1.41), and the sample was relatively diverse, as self-identified by the participants (53.6% were White, 17.9% Unreported, 10.7% Black or African American, 8.9% Asian, 5.4% Hispanic or Latino, 1.8% American Indian/Alaska Native, and 1.8% Other). Participants were recruited through a psychology department research participant group website and received partial research credit for an Introductory Psychology (PSY 101) course. All students for whom English was their native language were eligible to participate in the screening session which included a series of screening questions (i.e., medical history) and self-report measures (i.e., assessment of physical and relational aggression). In the initial screening session, 715 students participated. Reported use of current psychoactive medication, severe head injury, history of seizure activity, vision or hearing problems, and neurological disorder served as exclusionary criteria for the ERP study. Students thus deemed eligible via the screening were invited to a second follow-up session to participate in the ERP study. Email invitations were sent to 526 (196 female) potentially eligible students with instructions on how they could sign up on the secure Research Participants Group website for a follow-up session to participate in the ERP study. Of these, 112 (67 males and 45 females) signed up and attended one of the participation time slots and received additional research credit for the PSY 101 course.

The mean duration of time between sessions was 29 days (SD = 28 days; Median = 24 days). Reading level, as assessed by the Wide Range Achievement Test, was also measured prior to participation in the ERP study and all participants had a 5th grade reading level or higher. Those who participated in the ERP study ($M=24.05$, SD = 8.36) were not significantly different on self-reported relational aggression [$F(1, 701)=1.37$, $p=0.711$] than those who completed the screening questionnaire ($M=23.74$, SD = 8.31), but those participants who took part in the ERP study ($M=12.31$, SD = 6.71) were significantly higher in self-reported physical aggression than those who did not participate ($M=10.42$, SD = 5.22; $F(1, 702)=11.17$, $p=0.001$). Those who participated were not significantly different than those who only participated in the screening on any of the other variables of interest. This discrepancy could be due to our selection process. In selecting participants for the ERP study, in order to increase variability in the sample, email invitations to participate in the ERP study were sent first to individuals who were above the mean on relational aggression, physical aggression, or both. However, our main research question pertained to the role of relational aggression and the relational aggression construct did not exhibit a significant difference between the ERP study sub-sample and the original screening sample. Yet, the significant differences in reported physical aggression do suggest the need to interpret the results pertaining to physical aggression with caution.

3. Measures

3.1. Self-report of relational aggression

Participants completed the Self-Report of Aggression and Social Behavior Measure (SRASBM) to assess aggressive behavior (Morales and Crick, 1998; Linder et al., 2002). This measure was completed at both the first session and at the follow-up ERP session. All included regression models use aggression reported at the first session. The SRASBM was originally created to assess aggression and social behavior in romantic and peer relationships (Linder et al., 2002); however, Linder et al. (2002) only reported on the romantic relationship items. The measure has more recently been adapted to assess emerging adult peer relationships as well (Bailey and Ostrov, 2008; Lento-Zwolinski, 2007). This measure has a total of 39 items, including 11 items that measure relational aggression (e.g., “When I am not invited to do something with a group of people, I will exclude those people from future activities”) and six items that measure physical aggression (e.g., “I have pushed and shoved others around in order to get things that I want”). Additional items assessed relational and physical victimization, exclusivity, and prosocial behaviors, but were not analyzed for the purposes of this study. All responses are made on a seven-item scale from one (“Not at all true”) to seven (“Very True”). Total scores for relational and physical aggression were computed by summing all of the items within each respective subscale such that higher scores indicated higher levels of aggression. The SRASBM has demonstrated appropriate internal consistency within an emerging adult, college population (Cronbach's $\alpha=.73$, Linder et al., 2002; α's ranging from .69–.79, Bailey and Ostrov, 2008). In the present study, the subscales for relational aggression (Cronbach's $\alpha=.82$) and physical aggression (Cronbach's $\alpha=.90$) had appropriate internal consistency. Further, test–retest reliability was .86 ($p<.001$) for reported relational aggression and .87 ($p<.001$) for physical aggression.

3.2. Assessment of intent attributions

To assess participant's report of relational and instrumental intent attributions and feelings of distress in response to socially ambiguous situations, a revised version (Bailey and Ostrov, 2008) of a standard measure of hypothetical-situation vignettes of socially ambiguous relational and instrumental provocation situations, based on Crick (1995), was used.[1] Vignettes were revised to be ecologically valid and appropriate for use with emerging adults (e.g., using more relevant stimuli, such as an MP3 player, and settings, such as a residence hall). Participants were asked to imagine that the events in the 10 stories were happening to them. Four stories depicted relational provocation situations focusing on potential rejection (e.g., hearing two students discuss a party that you have not been invited to). An additional four stories depicted instrumental provocation situations (e.g., a student spilling a drink over your back). Two benign stories were also included to avoid response bias. For each story, the participant indicated a reason for the provocation with two options indicating hostile intent scored as 1, such as "The student doesn't want me to come to the party" and two indicating benign intent scored as 0, such as "The student was planning to invite me later." A second question asked whether the student was trying to be (scored as 1) or not trying to be mean (scored as 0). Responses to both questions for their respective vignettes were added to create a score for hostile attribution biases. In addition, to avoid negative response biases two positively toned prosocial vignettes (e.g., a student leaving a seat when you are looking for a seat) were included for which participants indicated whether the intent was benign (e.g., "the student wanted me to have the seat") or whether there was no intent (e.g., "the student forgot something"). In four independent samples and studies, with younger participants (Crick, 1995; Crick et al., 2002; Leff et al., 2006; Yeung and Leadbeater, 2007), Cronbach's α levels ranging from .65 to .85 for the items assessing hostile intent attributions for relational provocation situations and .77 to .88 for instrumental provocation situations were demonstrated. In a study using emerging adults and the revised measure, Bailey and Ostrov (2008) reported acceptable internal consistency for instrumental provocation situations (α = .71) and marginal internal consistency for relational provocation situations (α = .64). In addition, Leff et al. (2006) reported a two week test–retest reliability of .79 for relational situation items and .82 for instrumental situation items. In the present study, Cronbach's α for hostile attribution biases for relational provocation situations was .72 and .71 for hostile attribution biases for instrumental provocation situations.

3.3. P300 task

The P300 event-related potential was elicited using an auditory perseveration task (Bauer and Hesselbrock, 2003). The task involved the presentation of two pure tones: a high-pitched tone (1000 Hz) and a low-pitched tone (500 Hz), as well as a white noise burst via headphones. The task contained 160 pure tones (i.e., 80 high-pitched and 80 low-pitched) and 40 white noise bursts. Each tone or white noise burst was 70 dB in volume and all stimuli were calibrated in sound pressure level (SPL). Each stimulus was 50 ms in duration and presented randomly every 2.5 s. The order of the presentation of the auditory stimuli was randomized, but with the limitation that there were at least four pure tones between each white noise burst in order to allow for a pattern of responding to be established. Participants were instructed to press a button corresponding to either the high- or low-pitched tone (i.e., "press the button below the left-thumb in response to the low-pitched tone or the button beneath the right-thumb in response to a high-pitched tone"). Participants were also instructed that upon hearing the white noise burst, they were to reverse their responses to the pure tones (i.e., "press the button below the left-thumb in response to the high-pitched tone or the button beneath the right-thumb in response to a low-pitched tone"). All participants completed at least one practice trial to ensure comprehension. P300 ERP's elicited by the tone stimuli and white noise bursts (i.e., the cue to reverse responding) were recorded and measured. In addition, the number of trials on which the participant responded to the pure tone following the presentation of a white noise stimulus, but failed to reverse his or her response (i.e., perseveration error) was calculated (Bauer and Hesselbrock, 2003).

3.4. ERP recording methods

Each participant was seated in a sound- and light-attenuated chamber and was fitted with an electrode cap (Compumedics Neuroscan Inc.) containing 62 scalp electrodes located according to the International 10–20 system (Picton et al., 2000). Impedances were restricted to less than 5 kΩ for each electrode. All ERP data was amplified using a Neuroscan SynAmps channel amplifier system (Compumedics Neuroscan, El Paso, TX). Electrooculogram (EOG) electrodes were placed above and below the left eye (VEO) and on the side of the left and right eye (HEO). The amplifier gain was set at 20 K. Participants were grounded via an electrode on the forehead. All EEG and EOG channels were digitized at a rate of 1000 Hz. ERP data was filtered using a bandpass of 0.01–35 Hz. Data was re-referenced offline to two leads placed on each mastoid. EEG epochs were also examined for the absence of A–D converter overflow, voltage change >100 μV, and other movement artifacts. Eye blink artifact was removed as follows: trials contaminated by eye blinks were identified with a threshold of −250 mV. Eye blink ERPs were averaged and then transferred into spatial singular value decomposition (SVD) files. A spatial filter was used to subtract the SVD file from the continuous EEG.

The P300 in response to the white noise burst and the tone stimuli were identified as the most positive peak between 250 and 700 ms (Bauer and Hesselbrock, 2003). Peak P300 voltage was identified using an automated algorithm accompanied by manual visual inspection by a trained research assistant. Amplitude was defined as the μV deflection from the baseline to the peak. Latency was defined as the average milliseconds from stimulus presentation to the peak. P300 ERP's elicited by the white noise bursts (*M* number of trials retained = 36.60; SD = 4.30; Range = 21.00–40.00), the cue to reverse responding, as well as the low (*M* number of trials retained = 77.00; SD = 4.90; Range = 53.00–80.00) and high (*M* number of trials retained = 76.50; SD = 4.70; Range = 54.00–80.00) tones were recorded and measured.

4. Results

4.1. Preliminary analyses

Descriptive statistics for and inter-correlations between each of the constructs assessed are presented in Table 1. The correlations between the constructs ranged from low to moderate (r's ranging from .01 to .53), except for the correlation of .00 between hostile attribution biases for instrumental provocations and relational aggression. The relational and physical aggression variables (r = .53, p < .001) were correlated with each other, as were the hostile attribution biases variables for relational and instrumental provocations (r = .21, p < .001). Further, relational aggression and hostile attribution biases for relational provocation were correlated (r = .27, p < .01); however, physical aggression and hostile attribution biases for instrumental situations were not significantly correlated with each other (r = .06, ns). In addition, the correlation between hostile attribution biases for relational provocations and relational aggression (r = .27, p < .01) was significantly (z = 3.08, p < .01) higher than the correlation between hostile attribution biases for relational provocations and physical aggression (r = .00, ns). Importantly, assessments

[1] To reduce potential aggression priming, the assessment of hostile attribution biases was presented first in a packet of measures in the second part of the study, before the presentation of the SRASBM.

Table 1
Correlations and descriptive statistics between aggression constructs, attribution biases, and ERP constructs.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Age	–											
Physical aggression	−.19*	–										
Relational aggression	−.16	.53***	–									
Hostile attribution biases for relational situations	−.10	.00	.27**	–								
Hostile attribution biases for instrumental situations	.18	.06	.09	.21*	–							
Fz P300 amplitude (μV)	−.02	−.23*	−.13	.22*	−.02	–						
Fz P300 latency (ms)	−.02	.15	.32***	−.01	−.03	−.15	–					
Cz P300 amplitude (μV)	−.11	−.17	−.08	.14	−.09	.89***	−.12	–				
Cz P300 latency (ms)	.06	.08	.21*	.06	−.03	−.13	.76***	−.16	–			
Pz P300 amplitude (μV)	−.13	−.10	.03	.09	−.14	.55***	−.01	.78***	−.04	–		
Pz P300 latency (ms)	.06	.05	.10	−.03	.01	−.26**	.43***	−.27**	.52***	−.19*	–	
Perseverative errors	.18	−.17	−.08	−.02	.02	−.10	.08	−.12	.06	−.13	.11	–
M	19.34	12.31	24.05	12.29	9.19	16.81	350.40	20.21	347.10	16.74	360.41	10.77
SD	1.41	6.71	8.36	2.13	1.50	6.65	24.08	6.59	25.02	5.74	37.69	1.68
Range	18.00–24.00	6.00–38.00	11.00–56.00	8.00–16.00	8.00–14.00	−2.47–39.45	261.00–411.00	4.84–40.81	250.00–411.00	3.21–34.72	263.00–587.00	9.00–16.00

Note. *$p<.05$, **$p<.01$, ***$p<.001$.

of skew were less than three (−0.74 to 1.89) and kurtosis values were less than eight suggesting that non-normality was not a concern (Kline, 2005).

4.2. Topographical distribution of P300 amplitude

P300 amplitude served as the dependent-variable in a 3 (stimulus type: low tone, high tone, and white noise) × 5 (coronal region: frontal, fronto-central, central, centro-parietal, and parietal) × 5 (lateral location: left, mid-left, midline, mid-right, and right) repeated measures ANOVA. Electrode sites used for this analysis were F3, F1, Fz, F2, F4, FC3, FC1, FCz, FC2, FC4, C3, C1, Cz, C2, C4, CP3, CP1, CPz, CP2, CP4, P3, P1, Pz, P2, and P4. Grand average waveforms for the three stimulus types at midline electrode sites (Fz, Cz, and Pz) are depicted in Fig. 1. This analysis revealed main effects for stimulus type [$F(2, 216) = 464.20$, $p<.001$] and lateral location [$F(4, 432) = 30.40$, $p<.001$]. Bonferroni-corrected follow-up comparisons indicated that P300 amplitude in response to the white noise bursts was significantly larger ($p<.001$) than that of either tone stimuli (which did not differ from each other). Furthermore, consistent with prior P300 research (Fabiani et al., 2000), the P300 amplitude was largest for midline electrodes (i.e., Fz, FCz, Cz, CPz, and Pz) compared to electrode sites in the left or right hemispheres (p's<.001). Qualifying the main effects, this analysis also yielded a significant stimulus type × coronal region [$F(8, 864) = 62.40$, $p<.001$] interaction. Bonferroni-corrected follow-up analyses indicated that for both tone stimuli, P300 amplitude increased significantly from anterior to posterior regions with a maximum amplitude at the parietal region (p's<.01). However, for the white noise burst stimuli, all regional comparisons were significantly different from each other with a maximum amplitude at the central region (p's<.01).

Based on these findings, the white noise burst stimulus appears to be the most salient in terms of P300 amplitude in this sample. Prior work using this task has concentrated on the P300 response to the white noise bursts (Bauer and Hesselbrock, 2003) given its prominence as the signal for cognitive set-shifting. Thus, to reduce error associated with multiple comparisons of related variables, we chose to focus on the P300 response to the white noise burst stimuli at three midline electrode sites, Fz, Cz and Pz in the next analytic step. Midline sites were chosen given the larger P300 amplitudes at these locations and three coronal regions were chosen to provide a more comprehensive view of the relation between the variables of interest and the regional distribution of the P300. It is important to note that parallel analyses conducted using data from other electrode sites for the white noise burst stimuli produced fairly analogous findings[2] whereas analyses using the tone stimuli did not result in findings of central interest (see grand average waveforms at Fz, Cz, and Pz in response to white noise, high tones, and low tones for all participants presented in Fig. 1).[3]

4.3. Examining the linkages between aggression subtypes, hostile attribution biases, and P300

In order to examine the linkages between relational and physical aggression, hostile attribution biases, and the P300, a series of hierarchical linear regressions were run. In the first model (see Table 2), testing differences in P300 amplitude at the Fz electrode site, gender (i.e., coded as 1 for males and 2 for females) and age were entered at step 1 and relational and physical aggression were entered at step 2. Hostile attribution biases for relational and instrumental provocations were entered at step 3.[4] At step 1, neither age nor gender was a significant predictor of P300 amplitude at Fz. At step 2, physical aggression tended to negatively predict level of P300 amplitude at Fz [$F(4, 106) = 1.67$, $p = .162$, $\beta = -0.23$, $p = .054$] above and beyond the role of reported relational aggression, age, and gender, but the overall model was not significant. At step 3, hostile attribution biases for relational provocations predicted P300 amplitude at Fz [$F(6, 104) = 2.25$, $p = .044$, $\beta = 0.26$, $p = .012$] above and beyond the role of hostile attribution biases for instrumental provocations, relational aggression, physical aggression, age, and gender.

In the second model testing differences in P300 latency, gender and age were entered at step 1 and relational aggression and physical aggression were entered at step 2. Hostile attribution biases for

[2] For example, parallel analyses were run for P300 data from other electrode sites including F3, F4, C3, C4, P3, and P4. All models predicting P300 amplitude for frontal electrodes were consistent with the above described results for Fz data whereas central and parietal models were consistent with Cz and Pz results, respectively.

[3] All analyses were also run using P300 latency and amplitude at Fz, Cz, and Pz for the tone stimuli as the dependent variable. None of the predictors of interest were significantly associated with amplitude at Fz, Cz, or Pz for either of the tones. However, gender (i.e., female) predicted latency at Fz [$F(2, 108) = 3.82$, $p = .025$, $\beta = 0.25$, $p = .010$] for the low tone (i.e., 500 Hz) and relational aggression predicted latency at Fz [$F(4, 105) = 3.25$, $p = .015$, $\beta = 0.27$, $p = .016$] for the high tone (i.e., 1000 Hz).

[4] Gender differences between hostile attribution biases for instrumental provocations and relational provocations were explored, but were not significant. The interactions between relational aggression and hostile attribution biases for relational provocations and between physical aggression and hostile attribution biases for instrumental situations were also explored to investigate the potential relation between higher or lower levels of aggression and hostile attribution biases in predicting P300 amplitude and latency, but were not found to be significant.

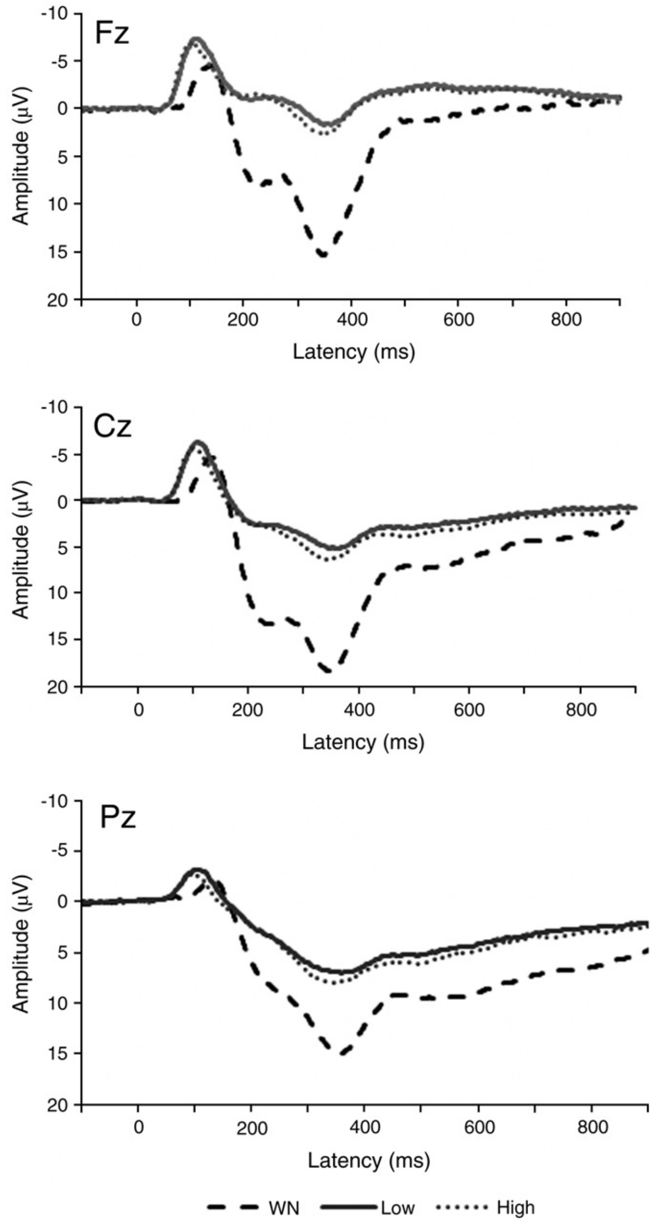

Fig. 1. Grand average waveforms at midline locations (Fz, Cz, and Pz) for all stimulus types ($N=112$).

relational and physical provocations were entered at step 3. At step 1, neither age nor gender was a significant predictor of P300 latency at Fz. At step 2, relational aggression predicted level of P300 latency at Fz above and beyond the role of reported physical aggression, age, and gender [$F(2,\ 106)=6.42$, $p=.002$, $\beta=0.32$, $p=.002$]. At step 3, relational aggression continued to predict P300 latency at Fz [$F(6,\ 104)=2.43$, $p=.031$, $\beta=0.36$, $p=.002$] above and beyond the role of hostile attribution biases for instrumental and relational provocations, physical aggression, age, and gender, but the ΔF was not significant. Therefore, results regarding the role of the relation between relational aggression and latency above and beyond hostile attribution biases should be interpreted with caution.

In the third model, there were no significant predictors of P300 amplitude at the Cz electrode site (see Table 2). In the fourth model, relational aggression was predictive of P300 latency at the Cz electrode site above and beyond the role of physical aggression, age, and gender [$F(4,\ 107)=2.46$, $p=.050$, $\Delta F(2,\ 107)=3.59$, $p=.031$, $\beta=0.23$, $p=.039$]. In the fifth and sixth models, there were no significant predictors of P300 amplitude or latency at the Pz electrode site (see Table 2).

In the seventh model testing differences in behavioral responses to set-shifting, or perseverative errors, gender and age were entered at step 1 and relational aggression and physical aggression were entered at step 2. Hostile attribution biases for relational and instrumental provocations were entered at step 3. At step 1, gender (i.e., female) and age were both significant predictors of perseverative errors. That is, women and older participants made more perseverative errors than men and younger participants. At step 2, physical and relational aggression did not significantly predict above and beyond gender and age. At step 3, neither hostile attribution biases for relational nor instrumental provocations were significant predictors.

5. Discussion

The purpose of this study was to investigate the role of hostile attribution biases for relationally provocative situations in predicting P300 ERP amplitude and latency, while controlling for relational and physical aggression. More generally, we investigated how frontal lobe functioning relates to the social-cognitive process of interpreting intent attributions. Due to the lack of research with relational aggression and relationally-based social information processing, we had anticipated that findings regarding hostile attribution biases for relational provocations might resemble those within the physical aggression literature.

To begin, we had expected that hostile attribution biases for relational provocations might be associated with lower amplitude. Although we partially replicated past research in that physical aggression tended to predict lower amplitude at the frontal (Fz) site in an earlier model step, our expectation that hostile attribution biases for relational provocations might resemble the physical aggression research was not supported. In regard to hostile attribution biases for relational provocations, we found that hostile attribution biases significantly predicted increases in P300 amplitude at Fz, above and beyond the role of hostile attribution biases for instrumental provocations, physical aggression, relational aggression, age, and gender. Furthermore, past researchers have hypothesized that larger P300 amplitude may reflect greater allocation of cognitive resources and enhanced "attending" for a given stimulus (Hillyard and Kutas, 1983; Wickens et al., 1983). This finding of greater sensitivity to a stimulus of interest may be related to the idea that individuals high in hostile attribution biases for relational provocation situations are overly sensitive to potentially salient stimuli. Arguably, these individuals are more vigilant or sensitive to cues within the tasks or interactions they are presented with and may potentially be providing more cognitive resources. It is of interest to note that this effect was not significant for the P300 amplitude at Cz and Pz sites. Although replication and additional research is necessary, this may suggest further support for the importance of frontal brain function in relation to hostile attribution biases and relational aggression in emerging adulthood.

We also anticipated that, similar to the previous research on physical aggression, hostile attribution biases for relational provocations may be associated with longer latency. We instead found that relational aggression was predictive of longer latency, above and beyond the role of gender and physical aggression. It could be that those exhibiting relational aggression may be more likely to show detriments in cognitive processing similar to prior studies of hostility and aggression which have suggested cognitive impairment in relation to increased P300 latency (Bond and Surguy, 2000; Mathias and Stanford, 1999).

We also explored the behavioral responses to the set-shifting prompts and investigated the role of hostile attribution biases for relational provocations and aggression in predicting perseverative

Table 2
Hierarchical linear regressions predicting P300 amplitude, latency, and perseverative errors.

Outcome, step and predictors	β	p	F, ΔF	R^2	ΔR^2
Model I: P300 amplitude at Fz					
1. Gender	0.10	ns	(2, 108) = 0.55, p = .581	0.01	
Age	0.02	ns			
2. PAGG	0.23	0.054	(2, 106) = 2.78, p = .067		0.05
RAGG	−0.02	ns			
3. RHAB	0.26	0.012	(2, 104) = 3.26, p = .042		0.06
IHAB	−0.05	ns			
Model II: P300 latency at Fz					
1. Gender	0.05	ns	(2, 108) = 0.17, p = .845	0.00	
Age	−0.01	ns			
2. PAGG	0.03	ns	(2, 106) = 6.42, p = .002		0.11
RAGG	0.32	0.002			
3. RHAB	−0.11	ns	(2, 104) = 0.71, p = .495		0.01
IHAB	−0.03	ns			
Model III: P300 amplitude at Cz					
1. Gender	0.09	ns	(2, 109) = 1.12, p = .331	0.02	
Age	−0.10	ns			
2. PAGG	−0.19	ns	(2, 107) = 1.66, p = .194		0.03
RAGG	0.00	ns			
3. RHAB	0.16	ns	(2, 105) = 3.26, p = .249		0.03
IHAB	−0.09	ns			
Model IV: P300 latency at Cz					
1. Gender	0.14	ns	(2, 109) = 1.27, p = .285	0.02	
Age	0.07	ns			
2. PAGG	0.05	ns	(2, 107) = 3.59, p = .031		0.06
RAGG	0.23	0.039			
3. RHAB	0.10	ns	(2, 105) = 0.15, p = .863		0.00
IHAB	−0.05	ns			
Model V: P300 amplitude at Pz					
1. Gender	0.15	ns	(2, 109) = 2.17, p = .119	0.04	
Age	−0.12	ns			
2. PAGG	−0.14	ns	(2, 107) = 0.77, p = .468		0.01
RAGG	0.10	ns			
3. RHAB	0.08	ns	(2, 105) = 0.97, p = .382		0.02
IHAB	−0.13	ns			
Model VI: P300 latency at Pz					
1. Gender	0.15	ns	(2, 109) = 1.47, p = .234	0.03	
Age	0.07	ns			
2. PAGG	0.10	ns	(2, 107) = 1.29, p = .280		0.02
RAGG	0.09	ns			
3. RHAB	−0.07	ns	(2, 105) = 0.22, p = .807		0.00
IHAB	0.02	ns			
Model VII: perseverative errors					
1. Gender	0.25	0.009	(2, 108) = 5.40, p = .006	0.09	
Age	0.20	0.033			
2. PAGG	−0.00	ns	(2, 106) = 0.15, p = .857		0.003
RAGG	−0.06	ns			
3. RHAB	−0.01	ns	(2, 104) = 0.03, p = .971		0.001
IHAB	0.03	ns			

Note. RHAB = hostile attribution biases for relational provocations, IHAB = hostile attribution biases for instrumental provocations, RAGG = relational aggression, PAGG = physical aggression, gender (1 = male, 2 = female).

responding. Within these analyses, none of the variables of interest significantly predicted perseverative errors. However, Bauer and Hesselbrock (2003) demonstrated that perseverative errors and P300 amplitude distinguish different maladaptive behaviors. These researchers reported that perseverative errors were associated with the rule violations subtype of conduct disorder whereas the aggression subtype of conduct disorder was associated with reduced P300 amplitude. Within the current sample, there was a small range of variability in perseverative errors (i.e., 9.00–16.00) possibly due, in part, to the high functioning college student sample that was presumably without severe psychopathology. This may have limited the ability to make comparisons on this factor. Yet, this lack of behavioral findings combined with significant effects related to the P300 may suggest, similar to the Bauer and Hesselbrock (2003) findings, that neurophysiological and behavioral indices may be differentially related to the constructs of interest (e.g., hostile attribution biases and forms of aggression in this case). Furthermore, the findings regarding the relation between the behavior of relational aggression and the cognition of hostile attribution biases for relational provocations are rather mixed (e.g., Bailey and Ostrov, 2008; Crain et al., 2005). However, for future research it may be important to investigate and replicate the present findings regarding relational aggression and associated social cognition with tasks more specifically related to relationship cues.

In summary, larger frontal P300 amplitude is hypothesized to reflect greater allocation of cognitive resources or enhanced "attending." There are potential implications for this enhanced and increased cognitive processing on social-cognitive interpretations. It could be that sensitivity to a stimulus of interest may be more broadly related to being overly sensitive to ambiguous cues, such as interpreting ambiguous cues as hostile. Similar P300 effects have been reported in other types of samples characterized by high levels of hostility (e.g., psychopathy; Flor et al., 2002; Raine, 1993), but this is the first known study to examine differences related to the type of provocation context related to hostile attribution biases. Importantly, this effect appears to be opposite of what has been found with physical aggression (Barratt et al., 1997; Gerstle et al., 1998; Mathias and Stanford, 1999). As was discussed, typically hostile attribution biases relevant to physical aggression are associated with less behavioral regulation and increased impulsivity (Hubbard et al., 2002), which is typically reflected as diminished P300 amplitude (Barratt et al., 1997; Gerstle, et al., 1998; Mathias and Stanford, 1999). This difference in terms of neurophysiological processing in relationally versus instrumentally provocative situations may be a result of relational aggressors using more complicated and arguably more cognitively taxing processes via language and manipulation to inflict or threaten harm. In exploring the impact of these constructs in predicting latency, longer latency is associated with decreased cognitive performance (Bond and Surguy, 2000; Mathias and Stanford, 1999). It may be that the more behavioral construct of relational aggression is associated with deficits, whereas the more cognitive aspect of hostile attribution biases is associated with increased attending. In addition, the findings within this study highlight the importance of studying both forms of aggression (i.e., relational and physical) and social information processing variables associated with both constructs. Further, the findings also underscore the relevance of considering relational and physical aggression as separate constructs (see Prinstein et al., 2001). It may not be appropriate to hypothesize that the associations between various constructs and relational aggression will resemble past findings with physical aggression. This may especially be the case when considering gender and differing forms of aggression (i.e., relational and physical) and related information processing.

5.1. Limitations and future research

This study is not without limitations. To begin, psychopathology was not directly assessed within the participants. Therefore, future research may want to more specifically probe the presence, and potential relation, that psychopathology may have within the context of investigating psychophysiological measures and relational aggression or relationally-oriented social cognition. Further, the assessment measures may have been limited. For example, the vignettes assessing hostile attribution biases may have been less relevant to students at a large university. Future research should include a wider variety of vignettes to assess whether the relationship context (i.e., familiar or unfamiliar peer or friend) is important (Burgess et al., 2006) or include probe questions after each vignette to address who the participants were thinking of while responding to the vignette.

In addition, the task used to elicit the P300 in this study was not directly relevant to the self-report of behavioral relational aggression and cognitive social information processing constructs assessed, and instead was based on responding to auditory tones. Therefore, this study was an important first step as standardized P300 methodology was used which allows for more direct comparisons with past research. However, another interesting area for future research would include combining ERP tasks and assessment of relational aggression variables, such as using ERP tasks more specifically related to relational variables. For example, tasks could combine novel hostile intent stimuli for participants to respond to instead of pure tones. Thus, the P300 may then be more directly related to socially and relationally relevant variables.

In addition, these findings call for future research integrating psychophysiological measures and relational aggression (e.g., Murray-Close and Crick, 2007) as such research may be important for furthering our understanding of the development and maintenance of relationally aggressive behaviors. Given that past research has focused on physical aggression, including explorations of the relation with P300 amplitude and latency (Barratt et al., 1997; Gerstle, et al., 1998; Mathias and Stanford, 1999), it seems that it would be beneficial to investigate the role of the forms (i.e., physical and relational) and functions (i.e., proactive and reactive) of aggression.

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