Journal of Anxiety & Depression

Research | Vol 6 Iss 1
ISSN: 2582-3264
https://dx.doi.org/10.46527/2582-3264.153

Electrophysiological Markers for Hostile Attribution Bias Among Individuals with Anxiety Symptoms

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Received: March 07, 2023; **Accepted:** March 24, 2023; **Published:** March 31, 2023

Abstract

Introduction: Anxiety disorders constitute the most prevalent subgroup of mental health conditions. While anxious individuals are more widely known as socially withdrawn and shy, recent research highlights a rather non-prototypical image, one that is aggressive. The main goal of this event-related brain potential study is to augment our knowledge of the neurophysiological response of hostile attribution biases of anxious individuals to ambiguous situations.

Methods: Using pre-collected data from a sample of 68 undergraduate and community-based adult participants, this study aims to explore the N400 deflection utilizing the Hostile Expectancy Violation Paradigm with anxious individuals, and whether the N400 deflection persists after controlling for aggression.

Results: A more negative amplitude was observed in response to a critical word that mismatched rather than matched with the person's expected hostile intention. Regression analyses revealed that anxiety scores negatively predicted the N400 following the mismatched expected hostile intention while controlling for reactive aggression. This suggests that the violation of hostile expectancy (non-hostile condition) regarding the intention behind an ambiguous, provocative behaviour is more pronounced among anxious participants. Conversely, for the violation of non-hostile expectancy (hostile condition), the overall model was significant, although anxiety scores did not account for the overall effect, reactive aggression did.

Conclusion: This study provides preliminary evidence that anxiety symptoms are uniquely related to hostile attribution bias independent of reactive aggression. Our results encourage an individualized approach to treatment as we now know that anxiety has specific cognitive distortions measurable through EEG. Future research should aim to replicate these findings with a clinically diagnosed sample.

Keywords: ***Anxiety; Reactive aggression; Hostile attribution bias; Electrophysiology; EEG; N400; Hostile expectancy violation paradigm***

Citation: Boulis M, Gagnon J. Electrophysiological Markers for Hostile Attribution Bias Among Individuals with Anxiety Symptoms. J Anxiety Depress. 2023;6(1):153.

1. Introduction

In 1994 Ricky Williams was considered one of the top running backs in the country, already a senior with over 25 touchdowns. Later in 1998, he solidified his career in college football history and was regarded as the best football player in the United States receiving the Heisman Trophy. He often conducted post-game interviews with his helmet and tinted visors in an effort to avoid eye contact. What no one knew was that beneath his 6-foot figure and 225 pounds of muscle was a regular guy who suffered from a social anxiety disorder. Although he was able to run across the football field in front of more than 80 000 viewers, his fear of being ridiculed caused him great anxiety when making small talk with teammates or participating in interviews [1]. According to the World Health Organization [2], anxiety disorders are ranked as the 6th largest contributor to global disability, while manifesting in nearly 3 million Canadian adults (11.6%; Statistics Canada, [3]). Often patients carry their symptoms for 5 to 10 years before they are diagnosed and treated yet fewer than 20% of them experience complete remission.

Anxiety disorders are more widely characterized by social withdrawal, shyness, and discomfort in social situations, yet recent research has demonstrated a non-prototypical aggressive image [4]. Individuals with anxiety disorders were found to express intense overblown anger and aggression, and significantly higher levels of anger and aggression compared to non-anxious individuals [5,4]. Surprisingly, some researchers have supported a link between social anxiety and aggression [6,7] as well as relational aggression [8]. Nonetheless, this body of literature is still underdeveloped and the literature that exists presents conflicting findings [9]. Thus, supporting the importance of further research on anxious individuals to understand potential cognitive mechanisms.

Social anxiety is not merely a fear of negative evaluations, but a chronic fear of rejection indicative of a distorted cognitive thought process. This fear of rejection often gives rise to feelings of hostility towards others as well as perceiving hostility in others [10]. According to Beck's [11] theory of anxiety, specific distortions in cognition like the interpretation of threat and danger in social situations are associated with both anxiety and aggression. Recent research efforts have provided support for distorted social-information processing among anxiety disorders [12]. For instance, anxious individuals detect more accurately fear-relevant words, and are more prone to threatening interpretations of ambiguous situations [13]. In fact, anxious individuals not only demonstrate a processing bias whereby they attend to more emotionally threatening information, but rather they also interpret ambiguous information as threatening.

Although the relationship between hostile attributions of intent and externalized behaviours like aggression is solidified in the literature, this link remains unresolved with internalized behaviours such as anxiety [14-17]. Furthermore, very few articles have described this maladaptive attribution of intent as being hostile in nature [9]. Such findings confirm the presence of maladaptive cognitive distortions but more importantly, they signal the presence of potential underlying aggression-related maladaptive schemas such as Hostile Attribution Bias (HAB).

Hostile Attribution Bias is the tendency to interpret ambiguous social context cues as negative or hostile in nature [18]. Although HAB has received attention in individuals with aggression it has not nearly received the same attention with individuals who are not only aggressive but display anxiety symptoms. Many researchers have expressed the importance of negative cognitive interpretations in individuals with anxiety but none to this date have explored HAB directly with individuals

both aggressive and anxious. Most of the research revolving around HAB utilise clinically aggressive subjects and measures of HAB often involve presenting social vignettes followed by open-ended or forced-choice questionnaires.

While hostility is a person's cognitive component of aggression, attributions of hostile intent are the inference of his mental state and its underlying neural mechanisms [18]. As such the use of Event-related potentials (ERP) have been consistently studied as a measure of brain functioning related to mechanisms involved in social cognition [18,19]. More specifically, the N400 component has been consistently used to explore violations of socio-emotional expectancies [20]. In other words, a larger N400 effect occurs when individuals are presented with unexpected words [21], words inconsistent with script-related knowledge [20], and words that are a poorer fit to the discourse context. The current study attempted to directly assess HAB rather than explore violations of socio-emotional expectancies by utilizing the Hostile Expectancy Violation Paradigm developed by Gagnon and colleagues (2016). According to Gagnon and colleagues, the Hostile Expectancy Violation paradigm is a promising tool to investigate basic mechanisms of thought associated with aggression. As authors managed to find that critical words that violated hostile intention expectations in the non-hostile condition elicited a larger N400 deflection among aggressive individuals compared to their non-aggressive counterparts. We believe that this paradigm has the potential for not only externalized behaviours but also internalized behaviours (i.e., anxiety). The current study is also based on findings from Gagnon and colleagues in both 2016 and 2017.

To our knowledge, only one study sought to examine HAB among anxious individuals [22], yet self-report measures were used to assess HAB. Self-report measures are unlikely to adequately assess existing cognitive schemas and associative networks, as they are often unconscious and activate automatically. Therefore, a direct real-time measure of attributional processes is required to further explore the underlying neural mechanisms between anxiety and HAB. Gaining a better understanding of the electrophysiological underpinnings between anxiety and aggression-related maladaptive schemas (i.e., HAB) is essential for devising effective treatments for anxiety symptoms and to improve existing treatments of other psychopathologies.

This study aims to augment our knowledge of the neurophysiological responding of hostile attribution biases in anxious individuals to ambiguous situations. First, we examined whether anxiety symptoms were uniquely related to the HAB, above and beyond aggressive traits. Therefore, it was expected that anxiety symptom scores would negatively predict the N400 amplitude in the non-hostile mismatch condition, after controlling for reactive aggression. Second, we predicted that higher anxiety symptom scores would positively predict the N400 amplitude in the hostile mismatch condition, after controlling for reactive aggression. HAB was measured via electroencephalography with a scenario of vignettes created by Gagnon et al. [16]. The data used for this project was gathered as part of a larger study entitled "Cognitive and neurophysiological mechanisms associated with the "Urgency" personality trait: theoretical and empirical integration" [23].

2. Method

2.1 Participants

87 participants were recruited from the university student population, the community, and ads placed on Kijiji. Respondents were then given a brief description of the study over the phone, followed by a screening interview as well as questions to assess inclusion and exclusion criteria. Those meeting the inclusion criteria were then informed of the additional study details.

2.2 Measures

The Brief Symptom Inventory (BSI) was used to assess clinical psychological symptoms, specifically, we utilized the scores of the items in the anxiety dimension. The reactive-Proactive Aggression Questionnaire RPAQ developed by Raine et al, [24] and its French-adapted version by Gagnon & Rochat, [19], was used to assess individual's reactions to aggressive situations. For this study, we utilized the reactive subscale. The Hostile expectancy violation paradigm developed by Gagnon et al. [16] was used to explore HAB, it consisted of multiple scenarios that were based on daily life social interactions. Each scenario contained three sentences: (1) Context sentence, used to indicate a hostile or non-hostile context; (2) Behavior sentence, where a character commits a social provocation directed towards the reader with ambiguous intentions; and (3) Intention revealed sentence, where the intention behind the provocateur's ambiguous behaviour is revealed. There were four conditions (see TABLE 1).

TABLE 1. **Examples of possible scenario sentences.**

First Sentence (social context)	**Second sentence (ambiguous behavior)**	**Third sentence (intention)**	**Context**
Non-hostile Before the exam, the class is quiet.	A friend walks by you and does not speak to you.	Non-hostile He does not want to *distract* you.	Non-hostile match (NHma)
Hostile Before the exam, the students stare jealously at each other.	A friend walks by you and does not speak to you.	Non-hostile He does not want to *distract* you. [a]	Non-hostile mismatch (NHmi)
Hostile Your co-worker is vengeful.	He comes to your desk.	Hostile He wants to *annoy* you.	Hostile match (Hma)
Non-hostile Your co-worker is working.	He looks at you.	Hostile He wants to *annoy* you.	Hostile mismatch (Hmi)

Note. That the target word is located at the end of the sentence in the French language. In French the pronoun "you" precedes the verb, which is describing the character's intention, resulting in the target sentence to finish with the critical word (i.e., a translates into "Il ne veut pas vous distraire").

2.3 Procedure

One hundred and fourteen participants were initially recruited to participate in the study. Forty-six participants were excluded due to: an incomplete BSI questionnaire and higher than a 20% rejection trial rate. The final sample was comprised of 68 participants who were informed of the EEG experiment and their consent was obtained. Participants were placed in a Faraday's cage and tested in low-level ambient light. Participants were instructed to read all scenarios carefully and encouraged to avoid making eye movements. Participants were told that the scenarios depict social interactions, and they should imagine as if they

were the ones in these interactions. Participants went through four practice trials before beginning 10 experimental blocks. A filler true or false comprehension question was randomly presented in each block to ensure participants were carefully reading. The mean correct response rate was 88%, indicating participants were reading for comprehension. Following the EEG procedure, all participants were given computerized versions of the RPAQ.

2.4 EEG recording

The EEG recording was adapted from Gagnon et al. (refer for more details; [16]).

2.5 Data analysis plan

For this study, signals at each electrode site were averaged for the four experimental conditions (NHmi, NHma, Hmi, Hma). This averaging was time-locked to the onset of the target word. An ANOVA was performed to determine regions of interest for the N400 effect. Correlational and ANOVA analyses were utilized to examine the relationship between the variables of interest. To verify our hypothesis, standard multiple regressions were performed to measure the combined effect of anxiety, reactive aggression, and age on the N400 obtained in the regions of interest. We examined the same six regions as Gagnon et al. [18,16]: Left and Right, -anterior, -central, -posterior. Statistical analyses were performed employing Huynh-Feldt corrected repeated measures ANOVA with variables: condition (hostile, non-hostile), consistency (match, mismatch), hemisphere (right, left), region (anterior, central, posterior).

3. Results

All analyses were re-conducted on 68 participants. A preliminary visual inspection of the global ERP trace displayed a pronounced ERP negative deflection, found between 450 and 650 ms for the non-hostile condition. According to Kutas and Federmeier [21], this negative deflection falls within the N400 time window. Data analyses showed an N400 effect in the non-hostile condition, indicating a violation of the expected hostile intention following a hostile context. N400 ERP amplitude was measured as the difference between the mean mismatch and the match conditions.

3.1 Analyses of variance

Since we were interested in the impact of violations of intention expectations, we examined the main effects of ANOVAs and interactions regarding the consistency factor and condition. Initially, the repeated measures ANOVA revealed a significant main Consistency effect. There was a significant interaction between Condition and Consistency (Huynh-Feldt=152. 5, F (1, 67)=21.7, p=.000), as well as condition, hemisphere, and region (Huynh-Feldt=6.6, F (2, 66)=18.2, p=.000). Such results are indicative of the presence of the N400 expected in non-hostile condition. Since this study is utilizing the same data from both Gagnon & Jolicoeur [23] and Gagnon et al.'s [17] study, we chose to comparatively examine the N400 amplitude for the hostile and non-hostile conditions of the ERP task, using the right hemisphere electrodes (central, posterior, and anterior). These regions were selected due to past research that found the N400 effect to be largest over centro-parietal sites, with a slightly right hemisphere bias for written words in sentences [21]. In addition, Gagnon et al., [17] have obtained greater component amplitudes for the non-hostile condition (non-hostile intent) than for the hostile condition (hostile intent), but also for the central and posterior electrode sites than for the anterior sites, and the hostile group than for the non-hostile group [17].

3.2 Correlations

A correlational table revealed links between BSI anxiety subscale scores, reactive RPAQ scores, and the non-hostile N400 right central. In addition, age was positively correlated with the non-hostile N400 right central but not sex. There was no correlation between BSI anxiety and Hostile N400 for any of the six regions (see TABLE 2).

TABLE 2. **Means, Standard Deviations, and Correlations.**

S. No.	Variable	*M*	*SD*	1	2	3	4	5
1.	BSI anxiety score	.90	.89					
2.	Reactive RPAQ score	9.68	4.31	.52**				
3.	Non-hostile right central N400 (μv)	-1.23	1.58	-.26*	-.15			
4.	Hostile right central N400 (μv)	.21	1.85	.13	.36**	-.20		
5.	Sex			.19	.05	.01	-.06	
6.	Age	26.23	7.84	-.01	-.01	.29*	.00	-.12

Note. M=mean and SD=standard deviation. * indicates p<.05. ** indicates p<.01.

3.3 Multiple regression

Models were first tested and found not multicollinear. For the first analysis, we examined the non-hostile condition, specifically using the right anterior N400 effect size. An overall significant effect was observed (F=2.48, p=.07), in which anxiety was a significant predictor of the N400 effect (β=-.29, t=-2.05, df=63, p=.04), whereas reactive aggression (p=.28) and age (p=.07) were not (see TABLE 3). Similarly, a multiple regression was conducted with the right central N400 for the non-hostile condition and found a significant overall effect (F=3.46, p=.02). While age (β=-.06, t=2.43, df=63, p=.02) was a significant predictor of the N400 effect, Anxiety (β=-.27, t=-1.98, df=63, p=.05) demonstrated a tendency for significance, while reactive aggression (p=.70) was not (see TABLE 4). Finally, a third multiple regression was performed using the right posterior N400 for the non-hostile condition. Results revealed no significant overall effect (F=1.40, p=.25).

TABLE 3. **Multiple Regression Using Non-hostile Right Anterior N400.**

	Standardized Coefficients				***Overall Model Fit***				
Variables	*B*	*SE*	*ß*	*t*	*Adj. R^2*	*df*	*MS*	*F*	*p*
Right anterior N400	-1.65	.82		-2.02	.07	63	5.87	2.48	.07
Age	.04	.03	.22	1.79					.07
BSI anxiety Scores	-.93	.06	-.29	-2.05					.04
Reactive RPAQ	.07	.06	.17	1.20					.28

Note. *B*=unstandardized coefficient, *SE*=standard error, *ß*=standardized regression coefficient, *MS*=mean square.

TABLE 4. **Multiple Regression Using Non-hostile Right Central N400.**

	Standardized Coefficients				**Overall Model Fit**				
Variables	*B*	*SE*	*ß*	*t*	*Adj.* R^2	*df*	*MS*	*F*	*p*
Right central N400	-2.22	.81		-2.75	.11	63	7.95	3.46	.02
Age	.06	.02	.29	2.43					.02
BSI anxiety Scores	-.88	.45	-.27	-1.98					.05
Reactive RPAQ	.02	.06	.05	.39					.70

Note. *B*=unstandardized coefficient, *SE*=standard error, *ß*=standardized regression coefficient, *MS*=mean square.

For the hostile condition, we examined the right anterior, central, and posterior. For the right anterior an overall significant effect was observed (F=2.94, p=.04), in which only reactive aggression (β=.19, t=2.84, df=63, p=.01) significantly predicted the N400 effect whereas anxiety scores (p=.11) and age (p=.42) did not. Similarly, in the right central an overall significant effect was observed (F=3.61, p=0.2), where reactive aggression (β=.44, t=3.17, df=63, p=.00), was the predictor of the N400 effect. In the same manner, we found no significant overall effect in the right posterior (F=2.45, p=0.72).

4. Discussion

A previous study showing that aggressive individuals infer more hostile intentions from others in ambiguous scenarios [16], raised the question of whether anxious individuals also demonstrate hostile attribution biases in ambiguous situations. In addition, Deschenes, Dugas and Gouin's findings [22], that individuals with GAD demonstrated more threatening interpretations and hostile attributions than their less anxious counterparts, sparked interest in examining HAB with robust methods in a complementary manner to questionnaires. The goal of this study was to examine the neurophysiological responding of hostile attribution biases in anxious individuals to ambiguous situations independent of reactive aggression. More specifically our first hypothesis was confirmed, in that BSI anxiety symptom scores negatively predicted the N400 amplitude in the non-hostile mismatch condition, even after controlling for reactive aggression. This effect was observed in the right anterior region in the non-hostile condition when reactive aggression was factored in as a covariate. In addition, in the non-hostile condition, anxiety scores tended to predict N400 scores in the right central region, with a p-value near significance.

Such results are in fact in line with aggression literature mentioned above that suggests a more pronounced N400 effect in the non-hostile condition, although stronger in centroparietal sites, and with slight right hemisphere bias for written words in sentences [21,16]. A potential explanation is that chronic activation of knowledge structures that represent aggressive schemas causes HAB in aggressive individuals. Over time, aggressive individuals build a more rapid schema for the activation of aggressive thoughts, and this is hypothesized to lead to more hostile attributions. Another potential explanation for our findings is that aggressive individuals can potentially be remembering negative cues from their past experiences and linking them to the current situation [25]. Similarly, can we speculate with our anxious participants, during the presentation of social scenarios, participants linked them to negative cues from past experiences, resulting in cue distortions.

Our findings are also in line with anxiety research that report negative interpretation biases (i.e., detect fear-relevant words, prone to threat interpretations) among anxious individuals [12]. More specifically, anxious individuals often fear others' negative evaluations [1]. This fear often points to a distorted thought process of how they perceive their social interactions. Which may point to specific distortions in the processing of social information. Potentially accounting for the fact that they interpret ambiguous situations as more hostile than less anxious individuals. Similarly, many anxiety studies have reported that anxious individuals often demonstrate hyper-vigilance to threats in ambiguous situations or attention bias to threatening information [26-28]. In fact, a core feature of social anxiety is hyper-vigilance about sources of potential social rejection and negative evaluations [10]. Thus, our findings that more anxious individuals interpret ambiguous social situations as hostile are consistent with the idea that the observed HAB among anxious individuals is explained by their hyper-vigilance for threat in ambiguous situations and potential rejection or negative evaluations. However, the relation between HAB and anxiety can be explained the other way around, where negative consequences of aggression on social interactions can maintain HAB as well as anxiety symptoms in aggressive individuals. More research is needed to disentangle the causal relationship between HAB and anxiety.

To our best knowledge, this is the first study to examine electrophysiological markers for HAB among anxious individuals utilizing Gagnon et al., [18]'s Hostile Expectancy Paradigm. Only one previous study attempted a similar research question, exploring the information processing styles of individuals with GAD [22]. Similarly, to our findings, authors concluded that individuals with GAD attributed greater hostile intent to provocateurs, where the intent of the provocateur was ambiguous in the social scenarios. The use of questionnaires in Deschenes et al.'s study [22] to assess HAB, is more suitable for exploring cognitive content rather than underlying cognitive processes. Our study attempted to bridge this gap and assess online social information processes utilizing ERPs which are proven effective in studying attributions of hostile intent [18].

According to previous research on the N400 and HAB, the N400 is expected in the right central and posterior sites [18,16]. However, in our study, the ERP component was found in the right anterior region. A potential explanation for such findings is that anxiety may be associated with the additional effort to integrate non-hostile stimuli in a hostile context. More research is needed to explore if HAB in anxious individuals is specifically associated with the anterior rather than posterior region.

Our second hypothesis, that higher anxiety symptom scores would correlate positively with the N400 amplitude in the hostile condition, after controlling for reactive aggression, was not confirmed. Contrary to our hypothesis, the overall model was significant, although anxiety scores were not significantly correlated with the N400 amplitude. Nonetheless, reactive aggression accounted for the overall significance which is consistent with Gagnon et al. [18] results that explained the observed N400 effect in the hostile condition to be associated with reactive aggression.

A noteworthy limitation is the use of a self-report measure to assess BSI anxiety symptoms scores. Although individuals differed on anxiety symptoms, they showed relatively low scores on the BSI anxiety subscale. This may be partly explained by the small non-clinical sample that was selected on hostility. Such a sample may differ from a clinical sample in anxiety symptom severity and aggression, depending on the anxiety disorder. Greater anxiety symptom levels could be anticipated in a larger clinical sample, potentially validating our results and conclusions further. This study provides preliminary evidence that anxious individuals interpret ambiguous situations as more hostile than less anxious individuals, independently of reactive

aggression. Our findings suggest that anxious individuals not only interpret ambiguous situations as threatening but also as hostile. Future research should aim to replicate these findings with a clinically diagnosed sample of individuals with anxiety and whether this effect is specific to types of anxiety disorders.

This study provides preliminary evidence that anxious individuals interpret ambiguous situations as more hostile than less anxious individuals, independently of reactive aggression. Our findings suggest that anxious individuals not only interpret ambiguous situations as threatening but also as hostile. Future research should aim to replicate these findings with a clinically diagnosed sample of individuals with anxiety and whether this effect is specific to types of anxiety disorders.

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