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BRIEF REPORT

AGGRESSIVE BEHAVIOR WILEY

Aggressiveness, inhibitory control, and emotional states: A provocation paradigm

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Abstract
The current study examines the effects of trait aggressiveness, inhibitory control and emotional states on aggressive behavior in a laboratory paradigm. One hundred and fifty-one adult participants took part (73 men, 71 women, and 7 nondisclosed). Event Related Potentials (ERPs) during a Go/No-Go task were utilized to capture the extent of inhibitory processing, with a laboratory provocation paradigm used to assess aggression. Contrary to the expectations, negative affective responses to provocation were negatively associated only with short-lived aggression and only among those with high past aggressiveness. Furthermore, past aggressiveness was related to a continuous increase in laboratory aggressive behavior regardless of the level of inhibitory control (P3 difference amplitude). However, feeling hostile was associated with short-lived aggressive behavior, only in those with lower levels of inhibitory control. These findings demonstrate the effect of distinct mechanisms on different patterns of aggressive behavior.

KEYWORDS
aggressive behavior, ERP, Go/No-Go task, information processing, P3 amplitude

1 | INTRODUCTION

Both the *General Aggression Model (GAM)* (Allen et al., 2018; Anderson & Bushman, 2002) and *I*^{3} *Meta-Theory* (Finkel, 2014) suggest that inhibition, which can prevent aggression, occurs during decision-making where different response options are evaluated against the situation a person is facing. DeWall et al. (2011), in their review of the literature, showed that poor self-control in general is associated with aggressive behavior. These inhibition processes can be captured by neural indices of inhibitory control, such Event Related Potentials (ERPs) and the amplitude of the third positive peak that occurs around 300 ms after the stimulus (P3) during the emotional Go/No-Go task. This P3 component is argued to reflect the extent of cognitive resources allocated to solving a specific task and relating to working memory and attention (Luck, 2014). Its amplitude at parietal and occipital sites also has an inverse association with externalizing behavior (Brennan & Baskin-Sommers, 2018), while its amplitude at frontal sites was negatively associated with aggression (Verona & Bresin, 2015).

Although in prediction tasks, P3 amplitude has been suggested to be associated with incorrect prediction, in the context of stop- and go-signals, P3 difference amplitude has been suggested to associate with general inhibitory control either indirectly (Huster et al., 2020), specifically frontocentral P3 difference amplitude, has been used as an index of inhibitory control (Gajewski & Falkenstein, 2013; Huster et al., 2013; Wessel, 2018). Harper et al. (2014) have reported larger frontocentral P3 amplitudes during the no-go trial than during the go trial, indicating involvement of this component in preventing a response. Messerotti Benvenuti et al. (2015) further specified this pattern by reporting larger P3 amplitudes at frontal and central sites as compared with that at parietal sites, especially for emotional rather than neutral stimuli. For example, in a sample of adolescents, Sun et al. (2020) found that those with high reactive aggression show lower frontocentral P3 amplitude in response to angry faces than those with low aggressive behavior. This suggests that when faced with provocation aggressive people show decreased inhibitory control. Meanwhile, Jabr et al. (2018) demonstrated that low levels of P3 amplitude at parietal sites served as a moderator for the effect of playing violent video games on aggressive behavior. As such, findings of smaller no-go P3 in persons higher on aggression agree with the GAM's description of inhibitory control. Higher P3 amplitudes among nonaggressive respondents suggest they utilized more cognitive control over their behavior, whereas those higher on aggression may not exert such control. It is, however, important to acknowledge that these studies assessed aggression via a self-report questionnaire rather than a behavioral paradigm. Whether the findings should show a similar pattern in the latter case remains to be tested. Given the aforenoted reports of P3 amplitude at frontocentral and parietal sites, as well as the potential relevance of partial sites in relation to emotional stimuli (Hajcak et al., 2010), these two location would be of primary interest.

Consistent with the notion of reactive aggression, negative affect also shows a relationship with aggression (Fabian, 2010). Siep et al. (2019) reported that individuals who committed violent offenses had higher levels of emotional activation as well as overregulation of emotions, as compared with those who have not committed an offense. Similarly, Verona et al. (2012) have demonstrated that individuals diagnosed with Antisocial Personality Disorder (characterized by impulsivity and aggression), show poor inhibitory control when faced with emotion-provoking stimuli. High emotional reactivity is thus suggested to impair the ability to exert inhibition over impulsive actions that, depending on personality, can include aggression.

Given this literature on the role of emotions and cognitive processing on aggression, the current study aims to examine the independent and interacting roles of individual-level propensities (e.g., trait aggression), inhibitory control during emotional task (no-go P3), and state affect in the enactment of aggressive behaviors rather than retrospective self-report of such actions. In addition, it aims to achieve this using a laboratory paradigm of aggressive behavior. It was predicted that the intensity of affective response to provocation would be associated with aggressive behavior and moderated by trait propensities toward such behavior. It was also predicted that P3 amplitude would moderate the effect of aggressiveness on aggressive behavior in response to provocation. Moreover, following the mechanisms of hostile attribution bias (HAB) (Klein Tuente et al., 2019) it was predicted that the strength of the association between hostility and laboratory aggressive responding will increase as the inhibitory control (no-go P3 amplitude) decreases.

2 | METHOD

2.1 | Participants

One hundred and fifty-one participants originally completed the study session. They were comprised of 73 men and 71 women, with seven participants who did not specify their sex. The average age was 29.33 (SD = 6.3) with a range of 18–47.

2.2 | Approval

The study was approved by the Institutional Review Board (IRB) at the University of South Florida (IRB#: Pro00030534). The full procedure is described in supplemental materials.

2.3 | Emotional Go/No-Go task

ERPs were recorded during participants' engagement with the Emotional-Linguistic Go/No-Go task (see Bozzay & Verona, 2023 for a detailed task description). This task requires participants to exercise their inhibitory control to respond to word features by pressing a button when the presented word is in a normal font but restraining from pressing any buttons when the presented word is in italicized font. The meaning and valence of the word do not affect these rules. However, presented stimuli included positive (e.g., mighty) and negative (e.g., hate) words matched on valence and arousal, and neutral words (e.g., lamp). This addition was based on their salience for participants with prior aggressive behavior, as cues evoking negative emotions were expected to reduce their processing (Verona & Bresin, 2015). There were 32 words per condition selected from the Affective Norms for English Words (Bradley & Lang, 1999) and six blocks per condition. Each block contained words of the same valence, however, for the current analysis go and no-go trials were collapsed across blocks. The presentation order was randomized within blocks, while the order of blocks was counterbalanced across participants. Each block contained nine No-Go trials (italicized font) and 23 Go trials (normal font). Each word was presented for 1400 ms and followed by a 750–1000 ms interval between trials.

2.4 | ERP components

During the Go/No-Go task, participant ERPs were recorded using Electrical Geodesics system hydrocel 64-channel sensor nets and amplifiers (EGI). Analog signals were digitized online at 250 Hz and bandpass filtered (0.15–200 Hz) and amplified using Net Amps amplifiers. Electrodes underneath the eyes embedded in the nets were used to record eye movements. Impedances were kept below 50 kΩ. Stimuli were presented on a flat-panel display using E-Prime software (PST Inc.), and behavioral responses were collected with a keypad interfaced with E-Prime.

The processing of the obtained data was completed in Netstation software. The average head was used for re-reference. The data were epoched 200 ms before and 800 ms after the stimulus onset, with a 0.10–30 Hz filter applied with a baseline correction. Trials with deflections greater than 140 mV in absolute value or with eye movements greater than 55 mV were discarded. For those channels where more than 20% of trials were discarded, bad channel replacement when the data from bad channels is replaced with data interpolated, using the spherical splines method, from the remaining ones, was performed. An average of 80% of Go trials and 77% of No-Go trials were retained. Within each condition, average ERP waveforms were calculated. The P3 component was defined as adaptive mean peak amplitude (±50 ms) within 400–600 ms poststimuli at frontocentral (average across three electrodes: midline and lateral left and right) and parietal (average across four electrodes: two midline and lateral left and right) sites. The selection of sites was primarily guided by previous research (Jabr et al., 2018; Sun et al., 2020; Verona et al., 2012). In the current study, P3 difference amplitude (no-go P3 amplitude—go P3 amplitude) was used to reflect inhibitory control.

2.5 | Self-report questionnaires

2.5.1 | Affective states

The *Positive and Negative Affect Schedule (PANAS)* (Watson et al., 1988) scale consists of 20 Likert scale items and has two subscales: Positive (PA) and Negative Affect (NA) (Crawford & Henry, 2004). Participants are presented with different states (e.g., "Excited" (PA) or "Scared" (NA)) and are asked to rate how they are feeling at a given moment on a scale ranging from 1 (Very slightly or not at all) to 5 (Extremely). The NA subscale includes one item asking about feeling hostile. Participants were asked to complete PANAS as to their "current" emotional state at 4-time points: (1) at the beginning of the laboratory session; (2) after completion of the Go/No-Go task; (3) after the provocation; (4) after the aggression phase. Change in affect in response to provocation was computed by subtracting PA, NA, and hostility at time 2 from those at time 3.

2.5.2 | Trait and history of aggression

The *Aggression Questionnaire (AQ)* (Buss & Warren, 2000) was used to assess trait aggression proneness. It is a self-report questionnaire with 34 Likert scale items, assessing physical aggression ("I may hit someone if he or she provokes me"), verbal aggression ("My friends say that I argue a lot"), anger ("At times I get angry for no good reason."), indirect aggression ("I have been mad enough to slam a door when leaving someone behind in the room"), and hostility ("At times I feel I have gotten a raw deal out of life."). The responses to the questions range from 1 (Extremely uncharacteristic) to 5 (Extremely characteristic). The *Life History of Aggression (LHA)* (Coccaro et al., 1997) interview was used to assess prior history of aggressive acts. While the LHA has three distinct subscales Aggressive Behavior Consequences and Self-Directed Aggression, only the subscale including past aggressive acts was used in the current analysis. It included frequencies of physical fighting, temper tantrums in response to frustrations, verbal aggression, unprovoked assaults or aggression toward others, destruction of property, and vandalism. The LHA was administered by doctoral students trained in it and supervised by a licensed clinical psychologist.

Participants were asked about the frequency with which they had engaged in 11 types of aggressive and antisocial behavior after the age of 13. Rather than providing a specific number for each question, participants were asked to select a category ranging from "never" (0) to "so many events they can't be counted" (5). While the LHA has three distinct subscales: aggressive behavior ("Physical fighting (e.g., history of physical fights with other people whether or not the subject started the fight or not)"), antisocial behavior ("Antisocial behavior involving the police (e.g., warnings, arrests and/or convictions for misdemeanor or felony offences"), self-directed aggression ("Suicide attempts"). Only the subscale including past aggressive acts was used in the current analysis

2.6 | Laboratory aggression paradigm

After completing the Go/No-Go task, participants engaged in a provocation task, where a confederate, with whom they met at the beginning of the session and who acted rudely toward them, gave them poor feedback on an essay they wrote about their qualities, including negative comments pertaining to personal qualities. To further provocation the confederate completed the evaluation faster than required and then their feedback form was accidentally left for participants to see. This completed the provocation phase. Afterward, in "supervisor-employee" phase started. In it, participants were asked to judge the correctness of the confederate's performance in a memory recall task, that participants have not completed themselves. This represented the aggression portion of the procedures. Following incorrect responses, participants could choose to deliver no electric shock (represented by the button 0) or choose an intensity of electric shock from 1 to 7.[1] However, they could not see or hear the confederate, instead, they saw a screen prompt telling them whether the confederate's response was correct or not. This phase incorporated four blocks each with 10 trials. This laboratory measure of aggressive behavior via the "supervisor–employee" cover story was developed by Buss (1961) and modified by Verona et al. (2009). For the overview of the procedure please see Figure 1. A more detailed description of the paradigm used in this study is provided in (Bozzay & Verona, 2023).

2.7 | Data analysis

Statistical analyses were conducted using R software. Since previous research using similar paradigms has shown that aggressive responses across blocks do not always show linear growth (Verona & Kilmer, 2007), the pattern of changes in the intensity of aggressive responses across all blocks was checked via growth models. Given that the relatively small sample size precludes identification of any but medium to large effects, all the analyses utilized bootstrapped 95% confidence intervals, based on 5000 samples, to increase the robustness of the effects highlighted by the analyses.

3 | RESULTS

3.1 | Descriptives and aggression growth models

The descriptive statistics and reliability indices for the sample are presented in Table 1 (Full sociodemographic description of the sample is provided in (Bozzay & Verona, 2023). Averaged waveforms for frontocentral and parietal P3 amplitudes during the Go/No-Go task are presented in supplemental materials (Supporting Information: Figures S1 and S2).

To establish the pattern of changes in the intensity of aggressive responding across blocks, growth models were utilized. The initial model for 124 participants[2] showed that the linear trend was significant, $F(1, 123) = 5.33$, $p = .023$. Similarly, the quadratic change was significant, $F(1,247) = 4.01$, $p = .046$. Moreover, the addition of the quadratic term significantly improved the model fit, $\chi^2 = 3.997$, $df = 1$, $p = .456$. These analyses demonstrated that aggressive behavior followed a quadratic trend, meaning that it increased across blocks two and three but decreased afterwards. Consequently, both average aggressive behavior (linear growth) across blocks and

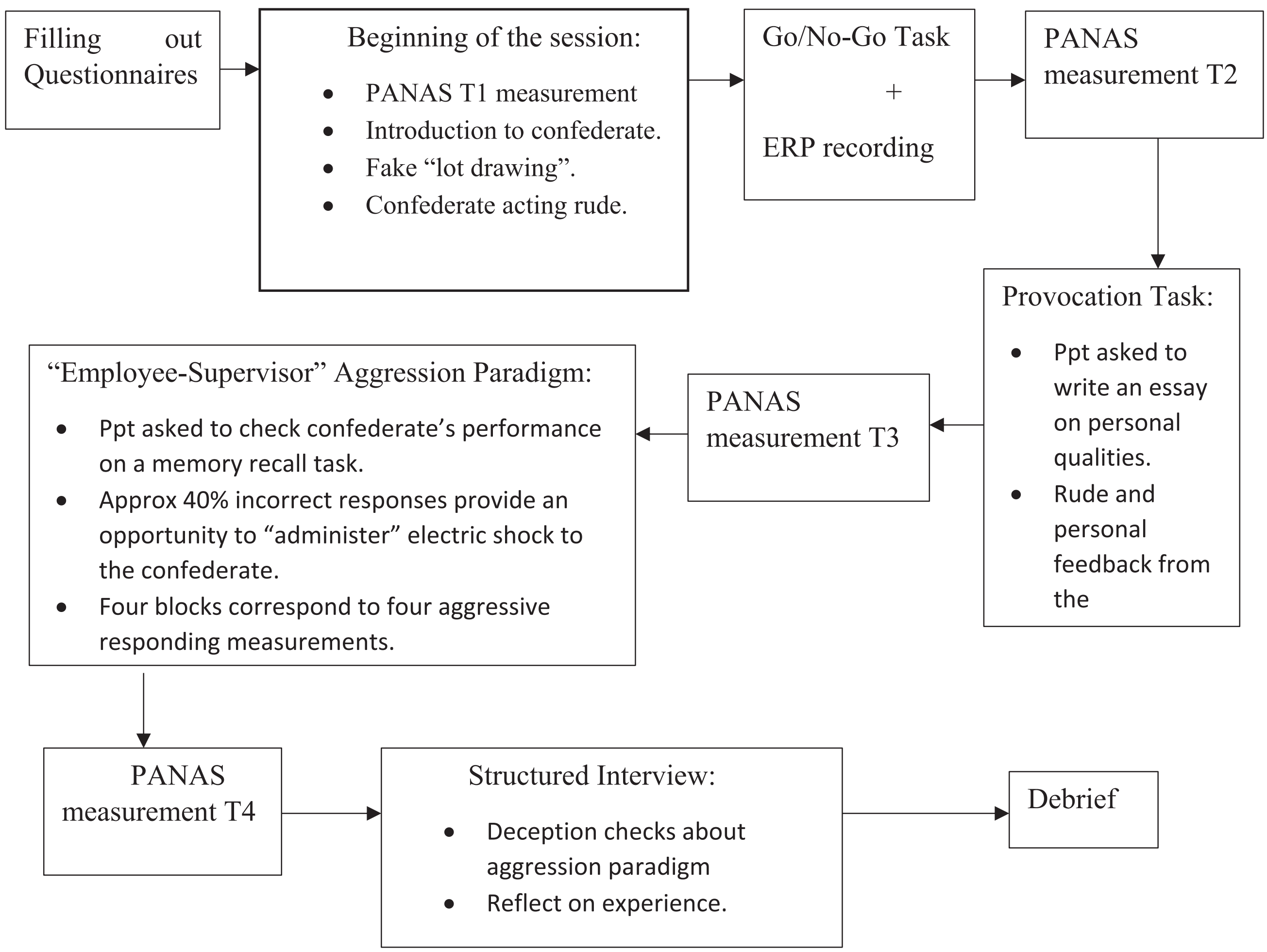

FIGURE 1 Overview of the study procedure.

TABLE 1 Descriptive statistics.

Variable name	Mean	SD
Average increase in aggressive responding (*n* = 124)	2.33	2.06
Quadratic increase in aggressive responding (*n* = 124)	0.38	2.19
Past aggressiveness (147)	36.78	11.02
Amplitude of change in negative affect during provocation (*n* = 138)	0.67	2.78
Averaged baseline hostility (*n* = 138)	1.12	0.45
Frontocentral P3 difference amplitude during Go/No-Go task (112)	1.30	1.45
Parietal P3 difference amplitude during Go/No-Go task (*n* = 112)	1.20	1.91

quadratic change in the analysis (see Supporting Information: Figure S3 for a visual representation of how aggression changed over four blocks).

3.2 | Affective responses to provocation

Principal Component Analysis (PCA) was first conducted to establish the composition of the PANAS subscales, as per previous work (Harmon-Jones et al., 2016). PANAS scores from 139 participants (excluding only those who had missing data on PANAS[3]) obtained in the beginning of the session (time 1) were used, as they represented participants' affect unaffected by anything related to the study. The two-factor solution based on eigenvalues above four and scree plot inspection for the first reduction point, with Oblimin rotation due to the expected correlation between the factors, showed that four items had a loading less than 0.5 (see Supporting Information: Figure S4 and Supporting Information: Table S1). Consequently, the calculation of PA and NA scores and changes in them were amended. When another PCA was run without these four items, the Bayesian Information Criterion (BIC) changed from − 258 to −168 providing strong evidence in favor of the new scoring.

Multiple linear regression of change in PA and NA in response to provocation on average aggressive responding across the course of the aggression task was not significant,[4] $F(2,121) = 0.60$, $p = .553$, and neither PA nor NA was associated with average aggressive responding, $B = 0.04$, 95% CI [−0.05, 0.13], $p = .338$, $B = -0.02$, 95% CI [−0.19, 0.10], $p = .734$. Likewise, the PA and NA model was not significant for quadratic change in aggression, $F(2,121) = 1.2$, $p = .304$, and changes in PA and NA were not associated with quadratic change in aggression, $B = 0.01$, 95% CI [−0.08, 0.10], $p = .753$, $B = -0.10$, 95% CI [−0.29, 0.01], $p = .152$.

Since hostility did not load onto the NA subscale and due to the effect of a hostile mindset on aggression (Anderson & Bushman, 2002; Klein Tuente et al., 2019), its association with aggressive behavior as an individual item was tested separately. To test the effect of hostility unrelated to the situation where a person has an opportunity to act aggressively, a baseline measurement of hostility from PANAS was chosen, which was indexed by averaging the ratings from two baseline measurement points. Average baseline hostility did not have a significant association with linear aggressive responding, adj. $R^2 = 0.02$, $F(1, 122) = 3.00$, $p = .086$; $B = 0.86$, 95% CI [−0.02, 1.46], $p = .086$. Although the p value indicated a significant association between averaged baseline hostility and quadratic aggressive responding, adj. $R^2 = 0.05$, $F(1,122) = 7.34$, $p = .008$; $B = 1.11$, 95% CI [−0.48, 2.15], $p = .008$, the 5000 bootstrapped confidence intervals include 0, suggesting this effect to be spurious.

3.3 | Affective responses and aggressiveness

The first set of moderation analyses examined whether changes in negative affect would interact with past aggressiveness to predict laboratory aggression. Supporting Information: Table S2 in the supplemental materials provides zero-order correlations for all included variables. To create an index of past aggression, Physical, Verbal, and Indirect aggression subscales from AQ as well as Aggression subscale from LHA were combined in a single index.[5] Its stability was verified using Confirmatory Factor Analysis (CFA). The resulting index had good CFI = 0.98, SRMR = 0.03; and AGFI = 0.90. All individual subscales had loadings above 0.50 (see Supporting Information: Figure S5), which were used as weights for the creation of past aggressiveness.

Moderation analysis revealed that past aggressiveness did not interact with changes in negative affect[6] for average aggressive responding (Table 2). However, past aggressive responding was positively associated with it, suggesting that those who engaged in such conduct in the past were more aggressive during the experiment. Meanwhile, when a quadratic change in aggression was used as an outcome the interaction was significant (Table 2). Subsequent simple slope analysis demonstrated that amplitude of change in NA during provocation was significantly and negatively associated with aggressive behavior only among those who had higher than average past aggressiveness, $B = -0.25$, 95% CI[7] [−0.42, −0.08], $p = .004$, but not among those who had average or below average levels of past aggressiveness, $B = -0.06$, 95% CI [−0.19, 0.09], $p = .403$ & $B = 0.137$, 95% CI [−0.07, 0.34], $p = .187$, respectively (Figure 2).

3.4 | No-Go P3 and aggressiveness

The next set of moderation analyses examined whether inhibitory control (P3 difference amplitude[8]) affected the relationship between past aggressiveness and laboratory aggressive responding (both average and quadratic change). Although the analysis

TABLE 2 Moderation models assessing the interaction between trait aggressiveness/past aggression with change in negative affect for aggressive behavior (*n* = 124).

	B [95% CI]	S.E.	*t*	*p*
Average shock across blocks adj. R^2 *= 0.05, F (3, 120) = 3.30, p = .023*				
(Intercept)	2.33[1.97, 2.68]	0.18	12.85	<.001
Change in negative affect	−0.01[−0.16, 0.11]	0.07	−0.08	.938
Past aggressiveness	0.04[0.01, 0.08]*	0.02	2.54	.012
Interaction	−0.01[−0.02, 0.01]	0.01	−0.85	.395
Average shock across blocks adj. R^2 *= 0.09, F (3, 120) = 4.87, p = .003*				
(Intercept)	0.32[−0.06, 0.69]	0.19	1.70	.092
Change in negative affect	−0.06[−0.20, 0.02]	0.07	−0.93	.353
Past aggressiveness	0.01[−0.02, 0.05]	0.02	0.74	.46
Interaction	−0.02[−0.02, −0.002]**	0.01	−2.97	.004

Note: For moderation analysis predictor and moderator were centered.
*<0.05.
**<0.01.

revealed a significant interaction between past aggressiveness and *frontocentral* no-go P3 index (no-go vs. go difference amplitude) on the average aggressive responding, the 5000 bootstrapped 95% CIs included 0 suggesting this effect to be spurious (Table 3). Meanwhile, the effect of past aggressiveness on the linear increase in aggressive conduct was significant and positive. This shows that the history of past behavior informs current behavior regardless of inhibitory control. Interestingly, when a quadratic change in aggressive behavior was used as an outcome no significant associations were found (Table 3).

Moderation analysis was also conducted with *parietal* no-go P3, in place of frontocentral no-go P3. Similarly to the previous moderation model, parietal P3 amplitude did not interact with past aggressiveness, which had a significant and positive association with aggressive behavior on its own (Table 3). Likewise, when the moderation model was run with quadratic change in aggressive behavior, there were no significant associations (Table 3).

The final set of moderation analyses examined the interactions between state hostility and P3 amplitude on aggressive behavior. Frontocentral P3 amplitude did not moderate the relationship between averaged baseline hostility and average aggressive responding but did moderate the relationship between

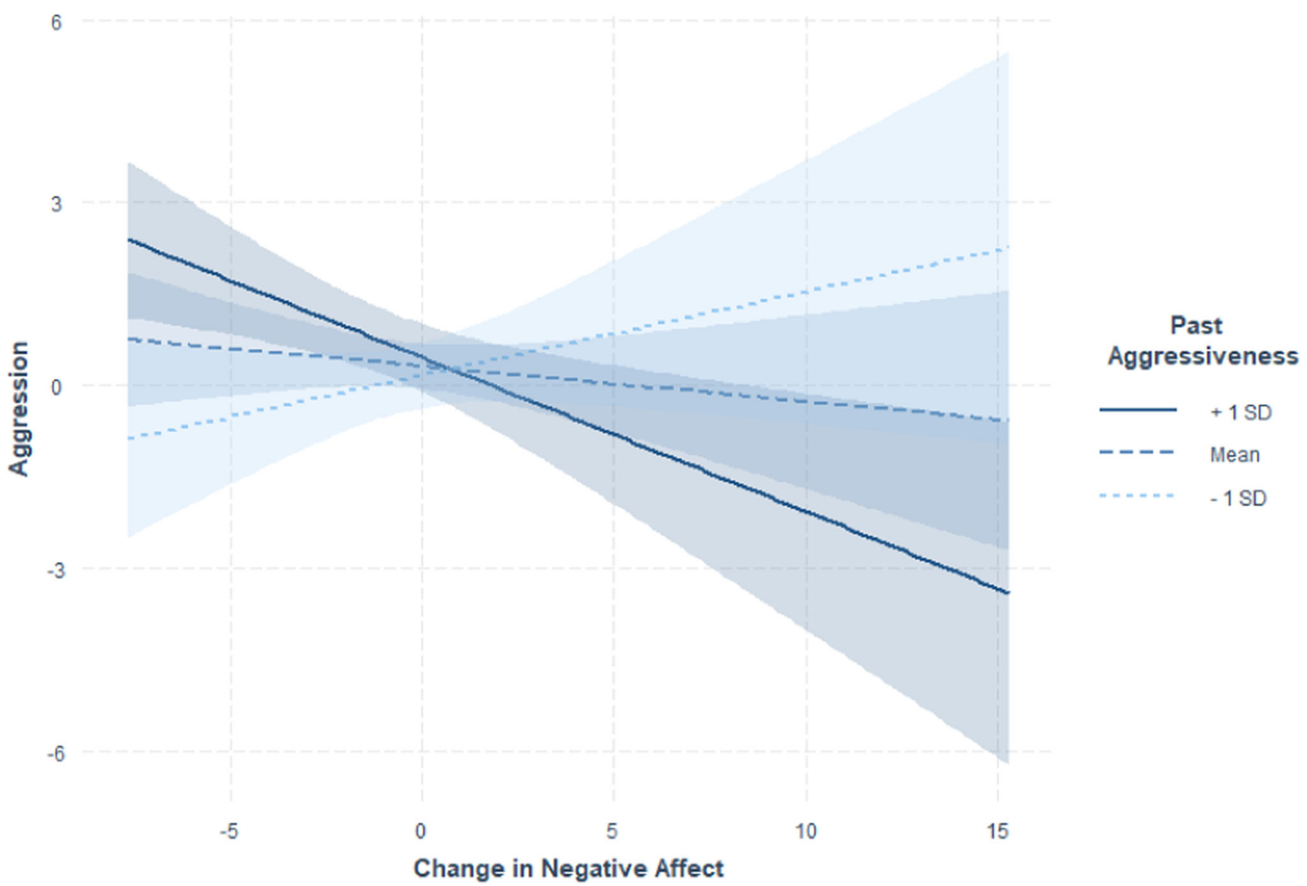

FIGURE 2 Simple slopes analysis for the interaction between change in negative affect and past aggressiveness on linear aggression. [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 3 Moderation analysis predicting aggressive behavior from past aggressiveness and P3 difference amplitude (n = 100).[a]

	B [95% CI]	S.E.	t	p
Average shock across blocks adj. R^2 = 0.11, F (3, 96) = 4.99, p = .003				
(Intercept)	2.40[1.99, 2.77]	0.19	12.29	.000
Frontocentral P3 amplitude	−0.07[−0.38, 0.17]	0.14	−0.49	.627
Past aggressiveness	0.05[0.02, 0.08]**	0.02	3.22	.002
Interaction	0.03[−0.001, 0.05]*	0.01	2.04	.044
Average shock across blocks adj. R^2 = 0.07, F (3, 96) = 3.461, p = .019				
(Intercept)	0.39[−0.04, 0.78]	0.22	1.81	.074
Frontocentral P3 amplitude	−0.27[−0.63, −0.001]	0.15	−1.78	.079
Past aggressiveness	0.03[−0.02, 0.07]	0.02	1.71	.091
Interaction	−0.03[−0.07, 0.001]	0.01	−1.85	.067
Average shock across blocks adj. R^2 = 0.10, F (3, 107) = 5.24, p = .002				
(Intercept)	2.40[2.01, 2.81]	0.20	12.22	.000
Parietal P3 amplitude	0.10[−0.20, 0.35]	0.12	0.84	.404
Past aggressiveness	0.06[0.02, 0.09]**	0.02	3.50	.001
Interaction	0.02[−0.01, 0.05]	0.01	1.92	.058
Average shock across blocks adj. R^2 = 0.02, F (3, 107) = 1.84, p = .145				
(Intercept)	0.44[0.03, 0.85]	0.22	1.94	.055
Parietal P3 amplitude	0.01[−0.25, 0.28]	0.14	0.04	.966
Past aggressiveness	0.03[−0.01, 0.09]	0.02	1.92	.058
Interaction	0.002[−0.02, 0.03]	0.01	0.14	.887

Note: For moderation analysis predictor and moderator were mean-centered.

[a]In addition to the exclusion of participants who did not comply with the aggression paradigm, 40 were also excluded during the ERP recording. Specifically, 22 had less than 50% of usable trials in either of the Go/No-Go conditions; 2 had corrupted data, 1 had missing data; 1 had corrupted file; 1 had invalid data, and from 13 participants ERP data could not be obtained.

*<0.05.

**<0.01.

averaged baseline hostility and quadratic change in aggression (Table 4). A simple slopes test specified that averaged baseline hostility was positively associated with a quadratic change in aggressive responding only at lower than mean levels of frontocentral P3 amplitude, B = 1.878, 95% CI [0.90; 2.86], p < .001. At mean and higher than mean levels of frontocentral P3 amplitude, hostility was not associated with a quadratic change in aggression, B = 0.428, 95% CI [−0.64, 1.50], p = .429, B = −1.02, 95% CI [−2.99, 0.95], p = .306 (Figure 3).

The regression models that used parietal P3 amplitude, instead of frontocentral, to predict aggressive responding found no significant interactions for average or quadratic change in aggressive responding (Table 4).

TABLE 4 Moderation analysis predicting aggressive behavior from hostility and P3 difference amplitude (n = 100).[a]

	B [95% CI]	S.E.	t	p
Average shock across blocks adj. R^2 = 0.01, F(3, 96) = 1.47, p = .227				
(Intercept)	2.34[1.95, 2.78]	0.20	11.47	.000
Averaged baseline hostility	0.83[−0.24, 2.77]	0.52	1.59	.115
Frontocentral P3 amplitude	−0.11[−0.47, 0.24]	0.15	−0.76	.451
Interaction	0.04[−2.05, 1.93]	0.40	0.11	.917
Average shock across blocks adj. R^2 = 0.14, F(3, 96) = 6.38, p = .001				
(Intercept)	0.38[−0.02, 0.83]	0.21	1.86	.066
Averaged baseline hostility	0.48[−0.54, 2.45]	0.53	0.92	.359
Frontocentral P3 amplitude	−0.31[−0.81, −0.06]*	0.15	−2.08	.040
Interaction	−1.03[−5.08, −0.04]**	0.40	−2.55	.012
Average shock across blocks adj. R^2 = 0.02, F(3, 96) = 1.73, p = .166				
(Intercept)	2.40[1.95, 2.84]	0.21	11.26	< .001
Averaged baseline hostility	1.37[−0.47, 3.72]*	0.69	1.99	.049
Parietal P3 amplitude	0.06[0.37, 0.38]	0.15	0.38	.708
Interaction	1.07[2.06, 3.26]	1.03	1.04	.301
Average shock across blocks adj. R^2 = 0.06, F(3, 96) = 3.02, p = .033				
(Intercept)	0.37[0.11, 0.94]	0.23	1.63	.107
Averaged baseline hostility	1.004[1.45, 3.59]	0.73	1.37	.173
Parietal P3 amplitude	−0.07[−0.52, 0.47]	0.16	−0.44	.662
Interaction	−0.60[−4.26, 3.71]	1.09	−0.55	.585

Note: For moderation analysis predictor and moderator were mean-centered.

[a]In addition to the exclusion of participants who did not comply with the aggression paradigm, 40 were also excluded during the ERP recording. Specifically, 22 had less than 50% of usable trials in either of the Go/No-Go conditions; 2 had corrupted data, 1 had missing data; 1 had corrupted file; 1 had invalid data, and from 13 participants ERP data could not be obtained.

*<0.05.

**<0.01.

4 | DISCUSSION

The current study looked at the independent and combined roles of inhibitory control processing and affective responses in facilitating aggressive behavior, especially among persons with a history of aggressiveness. Unexpectedly, negative affect and hostility did not consistently relate to engagement in aggressive behavior. However past aggressiveness moderated the relationship between change in negative affect and quadratic change in aggressive behavior (initial burst followed by waning over time). This type of aggressive

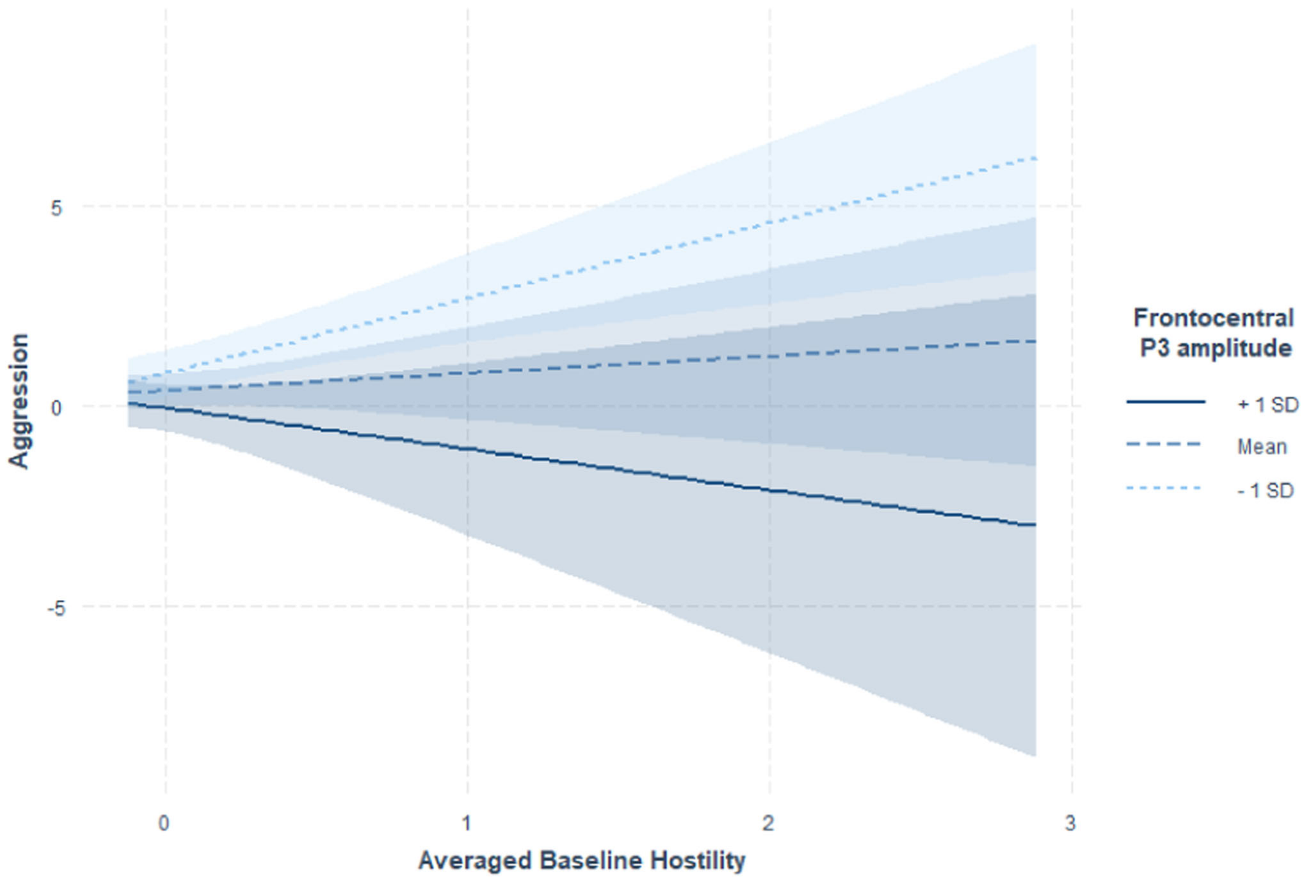

FIGURE 3 Simple slopes analysis for the interaction between averaged baseline hostility and frontocentral P3 difference amplitude on quadratic aggression. [Color figure can be viewed at wileyonlinelibrary.com]

responding was also positively influenced by prior feelings of hostility, but only among those who showed low levels of P3 difference amplitude during the Go/No-Go task.

Partially confirming the first prediction, the results demonstrated that the intensity of negative affect experienced during provocation, decreases aggressive behavior, only among those with high levels of past aggressiveness. Importantly, this association was present only for aggressive behavior characterized by an initial rapid increase followed by a decline (quadratic change), rather than a steady increase of such. This finding was unexpected as existing literature points to a positive relationship between NA and aggression (Allen et al., 2018; Burt et al., 2009; Megías et al., 2018). A plausible explanation for this effect is that for participants with high past aggressiveness increase in NA meant feeling overwhelmed and thus refocusing on improving their state rather than exerting injury onto others. Furthermore, it is possible that the association between the affect and aggression is only evidenced in populations where aggression is a predetermined problem, such as violent offenders (Siep et al., 2019). In this sense, it may only relate to forensic/clinical samples where there is a higher level of emotional activation evidenced prior (Siep et al., 2019; Verona et al., 2012). Meanwhile, the current sample included community participants. Such differences in the sample can also explain why the interaction between NA change and past aggressiveness was not significant for a linear increase in aggression. Another explanation focuses on the aggression paradigm where participants perceived their aggression *as necessary due to the demands of the situation* rather than due to their internal state. In such framework of aggression as "punishment" for the opponent, it resembles proactive (callous) rather than reactive aggression, which is used to describe quadratic aggressive responding (Fabian, 2010), and thus not strictly an assessment of pure emotional responsivity. In line with this assumption, a linear or steady increase in aggressive behavior was associated with higher levels of past aggressiveness.

Disconfirming the second prediction, neither frontocentral nor parietal P3 difference amplitude moderated the effect of past aggressiveness of aggressive behavior. However, past aggressiveness was consistently associated with a steady increase in aggressive responding during the experimental paradigm. Based on prior literature we used P3 difference amplitude to index inhibitory processing (Huster et al., 2013; Kropotov et al., 2011; Verona & Bresin, 2015; Wessel, 2018), which according to prior research has an inverse relationship with aggressive behavior (Jabr et al., 2018). Consequently, yielded results demonstrate that past aggressive behavior increases the likelihood of repeating such conduct regardless of a person's ability to allocate cognitive resources to inhibitory cues. As noted above this lends more support to the description of linear aggressing responding as proactive, rather than reactive (Fabian, 2010), as explosive quadratic aggressive responding was not associated with prior aggressiveness. Furthermore, the association between past and current aggressive behavior provides support for the GAM (Allen et al., 2018), according to which conduct in past social encounters informs behavior in future ones. Successful perpetration of aggression creates an easily accessible behavioral script that is activated as soon as a situation offers an opportunity to enact such behavior. If this was the case in the present study, then it is possible that the unimportance of inhibitory control was due to the ease of access to such script.

Lastly, the third prediction related to the effect of feeling hostile was partially confirmed. Experiencing hostility before the provocation was positively associated with quadratic aggressive responding, but only among those with low frontocentral P3 difference amplitude. This result aligns with several findings from previous research. First, feeling hostile could have facilitated HAB for interpreting the actions of the confederate during provocation and thereby increasing later aggressive actions toward the confederate (Klein Tuente et al., 2019; Rubio-Garay et al., 2016). Second, in this case, the previously reported inverse association between P3 amplitude and aggressive conduct was present (Jabr et al., 2018; Sun et al., 2020; Verona & Bresin, 2015). Furthermore, given that this effect was present as a moderator between feeling hostile and quadratic aggression, the description of the latter as reactive aggression gains more support. This in turn allows to specify that cognitive resources allocated to inhibitory cues can serve as a gatekeeper for aggressive behavior rising from emotional states rather than from calculated intentions. Participants with moderate or high P3 difference amplitude successfully inhibited the "impulse" to be aggressive stemming from their feelings of hostility. Importantly, this effect was present only for frontocentral P3 amplitude, which has been specified as an index for inhibitory control in the presence of emotional stimuli (Harper et al., 2014; Messerotti Benvenuti et al., 2015). Third, this result fits with the GAM's (Allen et al., 2018) supposition that a person's behavior in a given social encounter can be influenced by their state before they enter it.

The current study is not without limitations. The relatively small sample size allows only for the detection of medium to large effect sizes in moderation models. However, given the complexity of study design the emphasis on the quality of obtained data was placed above its quantity. Likewise, although the use of change scores in moderation models can be questionable, the aim of the study was to assess the effect of amplitude of change in affective response to provocation on aggression rather than assess the effect of negative affect at different time points. Furthermore, reliance on a single item to capture hostility decreases the rigidity of the findings. Nevertheless, we attempted to account for this by looking at this affective state at two-time points. Lastly, the use of P3 difference amplitude invites the possibility of it indexing multiple variables. Rather than reflecting inhibitory control, it could reflect more cognitive resources being paid to attention and processing the presented cues (Hajcak et al., 2010) or related to incorrect predictions about which trial (go or no-go) will be presented (Verleger et al., 2015). However, the aforenoted pattern of the results suggests that in this case its use as an index of inhibitory control is warranted conforms with existing studies advocation P3 difference amplitude and index of inhibitory control (Huster et al., 2013; Verona et al., 2012; Wessel, 2018).

5 | CONCLUSION

The results of this study have demonstrated a negative association between an increase in negative affect and subsequent aggressive behavior among those with high past aggressiveness, but a positive effect of feeling hostile beforehand and later aggressive behavior, among those with low P3 difference amplitude. While the former was present for linear or stable increase in aggressive behavior, the latter was present for quadratic change (increase followed by decrease) in aggressive behavior. This highlights that different patterns of aggressive behavior are influenced by different mechanisms. A more deliberate aggression is better explained by a past history of aggressive behavior, meanwhile, explosive but short-lived aggression is better explained by emotional experiences and poor inhibitory control. Furthermore, inhibitory control appears to play little role in modifying aggressive behavior in situations allowing for it when a person has a repeated history of engaging in such.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

All raw data were uploaded to the National Institute of Mental Health Data Archive (https://nda.nih.gov/edit_collection.html?id=2598). Procedures, protocols, and paradigms have been uploaded to the project repository on the Open Science Framework at https://osf.io/f34ht/.

ETHICS STATEMENT

The study was approved by the Institutional Review Board (IRB) at the University of South Florida (IRB#: Pro00030534).

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ENDNOTES

[1] In previous experimental session participants experienced these intensities

[2] Twenty-seven participants were excluded: 5 participants did not read the feedback, which was part of the paradigm, 7 participants saw through the deception in the aggression paradigm; 14 had missing data from the aggression task, 1 directed anger at the experimenter rather than confederate as per paradigm.

[3] Given the multiple steps involved in the study the missing data in the majority of cases related to the termination of the study at a previous step for data recording reasons (e.g., too much noise).

[4] This and the following model were run using data from 124 participants, the exclusion was either due to criteria related to aggression paradigm or due to missing data from the PANAS, which largely overlapped.

[5] We would like to thank the editor of Aggressive Behavior for this suggestion.

[6] As was noted beforehand this change was computed by subtracting the average Negative Affect ratings at timepoints and 1 and 2 from the rating at timepoint 3.

[7] This and following simple slopes analyses report nonbootstrapped CIs

[8] In previous analysis, frontocentral P3 difference amplitude was significantly and negatively correlated with commission errors in No-Go trials ($r = -0.31$, $p < .01$) and reaction time ($r = -0.30$, $p < .01$) suggesting that as more cognitive resources are allocated to processing inhibitory cues, behavioral response is more accurately and faster inhibited (Bozzay, 2019).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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