Executive Functioning in Provoked Physical Aggression

by

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ABSTRACT

EXECUTIVE FUNCTIONING IN PROVOKED PHYSICAL AGGRESSION

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Executive functions (EF) are higher-level control processes that regulate lower-level processes to shape complex performance. Although remaining an elusive construct, researchers have dichotomized EF into “cool” cognitive processes, such as cognitive flexibility, and “hot” emotional processes, such as decision-making. The current study investigated both “cool” and “hot” EF as moderators of the relation between provocation and aggression. Undergraduate participants (N = 224) completed measures of “cool” and “hot” EF. Aggression was measured using a modified version of the Taylor Aggression Paradigm in which participants blasted an ostensive “partner” after receiving positive or negative feedback. The Wisconsin Card Sorting Task was associated with aggression for males, but not for females; the Trail Making Test- Part B was not related to aggression; the Iowa Gambling Task was the strongest predictor of aggression for both genders. Findings highlight the importance of including measures of “cool” and “hot” EF in the assessment of aggression.
Dedication

This is for Bill and India.
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Executive Functioning in Provoked Physical Aggression

Over the past several decades aggression, defined as “any behavior directed toward another individual that is carried out with the proximate (immediate) intent to cause harm” (Anderson & Bushman, 2002), has become an area of considerable concern for society. Accordingly, extensive and growing literature has focused on determining the predictors of interpersonal aggression. Despite the scope of investigations, researchers remain divided with regards to specific causes of aggression. Indeed, theories of aggression range from an innate human instinct (Freud, 1923) to a learned social behaviour (Bandura, 1965). Despite the many competing theories, most research converges on aggression being the result of some type of provocation. For example, cognitive theories suggests that individuals are more aggressive if they interpret an event to be provoking [e.g. hostile attribution bias (Dodge 1980)], and drive theories suggest that external factors stimulate the desire to aggress [e.g. psychological frustration (Dollard, 1939)]. Berkowitz (1989) proposed a revised model of aggression indicating that frustration, in addition to many other types of negative affect, can lead to aggression.

Although most researchers agree that frustration and provocation lead to an increase in aggression, this is not the case for all individuals. Anderson and Bushman propose an integrative theory of aggression (General Aggression Model, GAM; 2002) that states that person factors (i.e., personality traits and genetic predispositions) and situational factors (i.e., provocation and frustration) interact to contribute to individual differences in aggression. According to their model, aggression does not stem from a solitary factor; instead, variation in aggression among individuals is the result of the interaction of many internal and external variables. Individuals can be provoked and individuals can become frustrated; however, not all individuals in those situations will demonstrate aggressive behaviour. Thus, determining variables that moderate aggressive behaviour will provide a better understanding of why some individuals are more inclined to aggress than others. One area that has been the focus of recent research on interpersonal aggression is executive functioning (Godlaski, & Giancola, 2009; Morgan & Lilienfeld, 2000). The current study seeks to extend previous research on the associations between executive functioning and aggression in an effort to clarify the role executive functioning plays in moderating physically aggressive behaviour.
Aggression and Executive Function

Executive function (EF) is broadly defined as a collection of processes responsible for the ability to monitor and control one's thoughts, emotions, and actions (Gioia, Isquith, Guy & Kenworthy, 2000). EF are higher-level control processes that regulate lower-level processes to shape complex performance, and include behaviour inhibition, attentional control, goal-selection, planning, abstract reasoning, cognitive flexibility, working memory, and decision-making (Anderson, 2002; Hoaken, Shaughnessy, & Pihl, 2003; Morgan and Lilienfeld, 2000). Disruptions to, or deficits in, EF can manifest as various behavioural inhibition difficulties, including aggression, impulsivity, and poor interpersonal skills (Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001). Although debate persists, most developmental and neuropsychological reports conceptualize EF as involving multiple inter-related processes that work together as a complex system, generally located in the pre-frontal cortex (Anderson, 2002; Gioia et al., 2000; Zelazo & Müller, 2002).

Research using aggression-prone clinical populations has supported the relationship between EF deficits and aggression. Conduct-disordered adolescents were found to have poorer performance on measures of EF than controls (Giancola & Mezzich, 2000; Lueger & Gill, 1990). Lower scores were found on measures of EF for adult violent offenders (Valliant, Gristey, Pottier, & Kosmyna, 1999), and for violent alcohol-dependent adult males (Easton, Sacco, Neavins, Wupperman, & George, 2008) compared to controls. Studies using a laboratory manipulation have provided further evidence for an association between EF and aggression (Godlaski, & Giancola, 2009; Hoaken et al., 2003; Lau, Pihl, & Peterson, 1995). Overall, a meta-analysis of the relation between antisocial behaviour and EF found the effect size between antisocial and comparison groups to be in the medium to large range ($d = .62$; Morgan & Lilienfeld, 2000).

More recently researchers have dichotomized EF into “cool” mechanistic and cognitively-based processes associated with the dorsolateral prefrontal cortex (DL-PFC), such as planning and attentional control, and “hot” emotionally-based processes associated with the ventromedial prefrontal cortex (VM-PFC), such as decision-making and social behaviour (Chan, Shum, Toulopoulou, & Chen, 2008; Zelazo & Müller, 2002).

The assessment of EF in the field of aggression research has focused traditionally on measuring “cool” cognitive processes that are unrelated to emotion (Zelazo & Müller, 2002).
Two of the most frequently administered measures of “cool” EF are the Wisconsin Card Sorting Task (hereafter, Card Sort), which assesses cognitive flexibility with rule change (Heaton, Chelune, Talley, Kay, & Curtiss, 1993) and Part B of the Trail Making Test (hereafter, Trail B), which assesses cognitive flexibility and sequential processing (Reitan, 1958). Although appropriate for “cool” EF, traditional measures such as the Card Sort and Trail B, do not assess “hot” executive processes that involve affective or social importance (Chan et al., 2008; Zelazo & Müller, 2002).

Until recently, there was no method by which to measure “hot” EF. As a result, Bechara, Damasio, Damasio, & Anderson (1994) proposed an affect-related task intended to simulate the rewards, punishments, and uncertainties present in real life decision-making. The Iowa Gambling Task (hereafter, Gambling) is a card game wherein participants are instructed to collect as much money as possible by selecting a card from any of four decks. Undisclosed to the participants, however, is that selecting from two of the four (disadvantageous) decks will result in large immediate gains combined with even larger losses for a negative end value, whereas selecting from the other two (advantageous) decks will result in smaller immediate gains and even smaller losses for a positive end value. Performance is based on balancing immediate rewards with long-term risks (Lakey, Rose, Campbell, & Goodie, 2008). Continuing to choose disadvantageous decks rather than shifting to more advantageous decks represents a deficit in affective decision-making, an aspect of “hot” EF (Hongwanishkul, Happeney, Lee, & Zelazo, 2005). Research suggests that the Gambling task is a reliable and valid measure of affective decision-making with various populations (e.g. Bechara et al., 1994; Ernst et al., 2003; Mitchell, College, Leonard, & Blair, 2002).

The connection between EF and aggression has been generally accepted, and results with clinical populations with a heightened propensity toward aggression support a distinction between the two types of EF. For example, evidence indicates that adolescents with behaviour disorders performed more poorly than healthy adolescents on the Gambling task (Ernst et al., 2003), and that adolescents with ADHD made more disadvantageous selections than controls (Toplak, Jain, & Tannock, 2005). Studies with adults have provided similar findings: both psychopathic individuals (Mitchell et al., 2002) and individuals with antisocial traits (Mazas, Finn, & Steinmetz, 2000) have a tendency to choose disadvantageously on the Gambling task. Although limited in quantity, recent studies provide evidence for an association between
aggression and emotionally-based EF. Despite recent advances in the area of affective-based executive processes, additional research is necessary to clarify the various processes that contribute to aggression, including both “cool” and “hot” EF, and whether these distinct aspects of EF are differentially related to aggression.

Further, there is a significant lack of research examining possible gender differences in the EF-aggression relationship. Results of meta-analyses consistently demonstrate that males are more physically aggressive than females (e.g. Archer, 2004; Bettencourt & Miller, 1996). Whether a result of observing and imitating others (i.e. Social Learning Theory, Bandura, 1973), an early division of labour (i.e. Social Role Theory; Eagly, 1987), or unequal parental investment (i.e. Sexual Selection Theory; Trivers, 1972), males and females display aggression differently. As a result, EF may moderate aggression differently for males and females.

The Current Study

The aim of the current study was to investigate the relationship between executive functioning and aggression following provocation in a university sample. First, the current study sought to replicate previous research demonstrating (cool) EF as a moderator of aggression. Second, this study sought to compare “cool” and “hot” EF as moderators of aggression. Third, given the consistent evidence that males and females display aggression differently, the EF-aggression relationship will be further explored using gender as a moderator. We expect that the EF model will apply more to males than females.

Method

Participants

Participants were 224 students (62% females) from the University of Guelph in southwestern Ontario (\(M = 18.6\) yrs.; \(SD = 1.2\) yrs.) who were recruited from an undergraduate participant pool in exchange for course credit. The sample was predominately White (80%). Ten participants were eliminated from the final sample as a result of technical difficulties. Participants met in a lab and completed a questionnaire package followed by computerized tasks in groups of one to three persons.

Measures

Demographics. Participants indicated their gender, age, and ethnicity.

Executive Functioning. Three frequently used indices of executive functioning (EF) were administered as computerized tasks. Two “cool” and one “hot” EF tasks were used (see Table 1).
The Wisconsin Card Sorting Test (hereafter, Card Sort; Grant & Berg, 1948; Heaton et al., 1993) is one of the most frequently used measures of “cool” cognitive EF, and assesses skills such as the capacity to shift set (versus perseverate). In this computerized version, four cards were presented to participants, each card varying in shape (circle, square, cross, triangle), color (red, green, blue, yellow), and quantity (1 to 4 objects). A sample card presentation could be four yellow squares. Cards were presented based on a rule that participants tried to determine. For example, several cards were presented all of which share the same color of objects. Participants were required to sort 64 additional cards into piles according to a changing rule. Participants were not instructed on how to sort the cards, but were told immediately whether their match was correct. Scores were based on the number of perseverative errors made by the participants. Perseveration entails delays in shifting to the new presentation rule. Results of a meta-analysis indicate that the Card Sort is sensitive to frontal lobe lesions (Alvarez & Emory, 2006). However, the authors note that lesion evidence does not support the WCST as a measure of specific frontal lobe lesions.

A second standard measure of “cool” EF is Part B of the Trail Making Test (hereafter, Trail B; Reitan, 1958), which assesses cognitive flexibility and sequential processing. In this paper and pencil task, participants were required to physically draw a line to connect a series of circles numbered 1 to 13 and lettered A to L, alternating from letter to number (i.e. 1-A-2-B, etc.) in the least amount of time. Scores were based on time to completion, with higher time representing poorer executive functioning. For ease of interpretation, the two measures of “cool” EF were reverse coded so that higher scores represented higher EF. Low scores indicate a deficit in EF. Research examining frontal lobe damage supports the sensitivity but not specificity of the Trail B (Reitan & Wolfson, 1995).

The Iowa Gambling Task (hereafter, Gambling; Bechara et al., 1994) was used as a measure of “hot” EF. In this computerized task, participants were presented with four decks of cards and were instructed to pick one card at a time from any of the four decks, with the goal of collecting as much money as possible. Participants were given a $2000 loan of play money and then were presented with a combination of gains and losses with each card selection (100 cards total). Unknown to participants, the decks differed in level of gain and loss. Selecting from decks A and B yielded high immediate rewards but even higher losses for an overall net loss, whereas choosing from decks C and D resulted in smaller immediate rewards but even smaller losses for an overall net gain. Scores were based on the number of selections from advantageous decks C
and D minus the number of selections made from disadvantageous decks A and B (i.e., \([C+D] – [A+B]\)). Thus, selecting more advantageous than disadvantageous decks yields a higher score, with higher scores representing higher levels of “hot” EF. Research suggests that the IGT is a reliable and valid measure of affective decision-making with various populations, including patients with damage to the ventromedial frontal cortex (Bechara et al. 1994; Buelow & Suhr, 2009).

**Aggression.** Consistent with previous research (Bushman & Baumeister, 1998; Godlaski & Giancola, 2009), a modified version of the Taylor Aggression Paradigm (TAP; Taylor, 1967) was used as a measure of aggression. Participants were told they would be competing against a same-sex partner (who was in fact non-existent) in a computerized reaction time task. The winner of each reaction time trial (total 9) was able to punish his/her partner by blasting the ostensive partner with an aversive stimulus (white noise). Participants set the duration and intensity of the white noise prior to the trial, which was administered to the losing opponent following the trial. Selections ranged from 1 to 5 seconds duration and from 60dB to 105 dB intensity. Settings were calibrated with a decibel meter. The mean sum of the standardized score for the duration and intensity of all noise blasts was used as a measure of aggression. The TAP has consistently shown to be a valid measure of aggression (Godlaski & Giancola, 2009; Hoaken et al., 2003).

**Validity.** The effectiveness of the deception (that participants were playing a reaction time task with an actual partner) was assessed via participant self-report as well as research assistant rating, which was largely determined on the basis of participant suspicion and degree of surprise upon debriefing. Following debriefing, participants rated their level of suspiciousness on an 11-point Likert scale ranging from 0 (not at all suspicious) to 10 (extremely suspicious). Research assistants rated level of participant suspiciousness using a 3-point Likert scale ranging from 1 (not at all suspicious) to 3 (very suspicious). Finally, participants rated how insulted, offended, and angry they were following the reaction time task using an 11-point Likert-scale ranging from 0 (not at all) to 10 (extremely).

**Procedure**

Participants were tested in groups of 1-3. They were informed that they would be interacting with a same-sex partner who was in another room. Participants were told that the current study sought to investigate reaction to feedback (positive or negative). Informed consent
was obtained after participants were told that the study would involve writing a short essay and competing in a reaction time task against a same sex partner. Participants then completed demographic information and measures of executive functioning. Tests were administered according to standard procedures.

Participants were asked to write a brief essay on abortion, and were told that their essay would be evaluated by their ostensive partner. In order to control for the effects of personal opinion about abortion, participants were randomly assigned to receive either a pro-life or pro-choice essay that had been written by their partner. Pre-written essays were identical in the pro-life and pro-choice conditions and handwritten to match the gender of the participant. Participants were randomly assigned to receive either positive or negative feedback on their essay, with the negative feedback acting as the provocation. Feedback was based on organization, originality, writing style, clarity of expression, persuasiveness of arguments, and overall quality, and included either a positive comment ("No suggestions, great essay!") or a negative comment ("This is one of the worst essays I have read!"). Participants evaluated the ostensive partner’s essay using the same form.

Immediately after receiving feedback (positive or negative) from their partner, the aggression paradigm was presented as a computerized reaction time task, wherein they would be competing against a partner. The winner of each reaction time trial (total 9) was able to blast his/her partner with an aversive stimulus (white noise). Participants were instructed to set the duration and intensity of the white noise prior to the trial, which would be administered to the losing opponent following the trial. Noise blast selections ranged from 1 to 5 seconds duration and from 60dB to 105 dB intensity. They were instructed that the opponent who clicked the square the fastest would be deemed the winner of the trial and would be able to administer the noise blast to the loser. Participants were informed that their partner received the same instructions. In actuality, the duration and intensity of blast selected by the partner, as well as the win/lose sequence of the trials, was predetermined by the computer program. Duration and intensity of the noise blasts were combined to calculate a mean measure of aggression. Upon completion of the reaction time task, indices of validity were assessed: suspiciousness, as well as self-reported distress. Participants were finally informed of the true purpose of the study and a debriefing form was provided.
Results

Manipulation Checks

The validity of the provocation manipulation in predicting aggression was examined by comparing group means across conditions. Consistent with previous research (Bushman & Baumeister, 1998), results reported significantly greater feelings of self-reported offense, \( t(222) = 2.92, p < .01, d = 0.39 \), insult, \( t(222) = 2.50, p = .05, d = 0.33 \), and anger, \( t(222) = 1.97, p < .05, d = 0.26 \), in the provocation condition as compared to the praise condition. Participants also behaved more aggressively in blasting their ostensive partner with higher levels of noise in the provocation condition than in the praise condition, \( t(222) = 3.09, p < .01, d = 0.41 \). Consistent with the model of (reactive) aggression and research demonstrating that provocation predicts aggression; subsequent analyses were conducted with only those participants in the provocation condition.

To further confirm the credibility of the deception manipulation, participants reported how suspicious they were. Research assistants also rated their perception of the participant’s level of suspicion to gain an additional point of validity. Participant self-ratings of suspicion correlated strongly with research assistant ratings of suspicion, \( r = .58, p < .001 \). There was a moderate correlation for both participant ratings, \( r = -.36, p < .01 \), and research assistant ratings, \( r = -.35, p < .01 \), of suspicion with aggression (see Table 1). Participants who were more suspicious were less aggressive, presumably because they were less engaged. Subsequent analyses will therefore control for participant and research assistant rated suspicion.

To further ensure the validity of the manipulation, a confederate acted as a participant in 10% of the sessions and monitored whether participants expressed suspicion about the study. Confederates reported that participants did not discuss topics related to the study, including any suspicion.

The Measurement of Executive Functioning

The general aim of the current study was to examine the extent to which executive functioning (scores on the Card Sort, Trail B, and Gambling) moderated the relationship between provocation and aggression. As a preliminary step, the construct of executive functioning had to be examined to determine whether the three measures of EF could be aggregated in total or aggregated into two separate measures by degree of affective engagement (“cool” vs. “hot” EF).
Results support the distinction between “cool” and “hot” EF. The two measures of “cool” EF (i.e. Card Sort and Trail B) were significantly correlated, $r = .31, p < .001$, though insufficient for aggregation (using $< .40$ as a cut-off; see Table 1). Neither measure of “cool” EF was significantly correlated with “hot” EF (Gambling). Given the multifaceted nature of executive functioning and its assessment, separate hierarchical regressions were conducted for each measure of EF (e.g., Hoaken et. al, 2003). Furthermore, correlations between measures of EF and gender were, Card Sort, $r = .02, ns$, Trail B, $r = -.05, ns$, and Gambling tasks, $r = -.06, ns$ (see Table 1).

Executive Functioning Predicting Aggression

Examining correlations between measures of EF and aggression, only the Card Sort, $r = .15, p < .05$, and Gambling tasks, $r = -.31, p < .01$, were significantly predictive of aggression (see Table 1). Gender was not significantly related to aggression as a zero-order correlate, $r = -.07, ns$.

Throughout subsequent hierarchical regressions, suspicion ratings were entered at step 1, main effects (gender, executive functioning measure) were entered at step 2, and the gender X executive functioning interaction was entered at step 3. Continuous variables (that is, measures of EF) were mean centered to increase interpretability. Gender was dummy coded (-1 = males, +1 = females). Following Bushman et al. (2009), and recognizing the limited power of multiple regression analysis to detect interactions among measures (Aiken & West, 1991; Chaplin, 2007), all effects in the subsequent analyses are reported, followed by a test of simple slopes. Analysis begins with the most widely used measure of executive functioning, the Card Sort task.

Card Sort. Over and above suspicion ratings entered at step 1 ($\Delta F(2, 111) = 10.40, p = .000$), which accounted for 16% of the variance, main effects entered at the second step accounted for an additional 4.1% of the explained variance, $\Delta F(2, 109) = 2.80, p = .07$. Main effects were found for Card Sort, $\beta = -.28, t(113) = -2.80, p = .006$, with a trend found for gender, $\beta = -.15, t(113) = -1.77, p = .08$. Of greatest interest was the gender X Card Sort interaction, which accounted for an additional 3.4% of variance, $\Delta F(1, 108) = 4.81, p = .03$. A test of simple slopes was undertaken (see Figure 1). Card Sort was assessed at high (+1 $SD$) and low (-1 $SD$) values (Aiken & West, 1991) with gender as a moderator. For males there was a significant association between Card Sort and aggression, $b = -1.04, t(113) = -2.85, p = .005$, whereas for females there was no significant relationship, $b = -.13, t(113) = -.62, p = .54$. Thus,
males were high on aggression when their EF (Card Sort) was low and low on aggression when their EF (Card Sort) was high, whereas females were low on aggression regardless of their EF score.

**Trail B.** Over and above suspicion ratings entered at step 1 ($\Delta F(2, 112) = 10.70, p = .000$), which accounted for 16% of the variance, main effects for gender and Trail B entered at the second step accounted for an additional 2.3%, $\Delta F(2, 110) = 1.58, p = .21$. Main effects were not significant for gender, $\beta = -.11, t(114) = -1.23, p = .22$, or EF-Trail B, $\beta = -.10, t(114) = -1.11, p = .27$. The gender X Trail B interaction accounted for a further 0.8% variance, $\Delta F(1, 109) = 1.11, p = .29$. The gender X Trail B interaction was, $\beta = .09, t(114) = 1.05, p = .29$. An examination of the simple slopes indicated that for males there was a negative trend in the relationship between EF and aggression (see Figure 2), $b = -.14, t(113) = -1.16, p = .11$. For females the relationship was not significant, $b = -.01, t(113) = -.09, p = .93$. Examined alternatively and splitting the file by gender, revealed a meaningful though nonsignificant correlation for males, $r = -.24$, though not for females, $r = -.04, ns$.

**Gambling.** Examining “hot” EF over and above suspicion ratings ($\Delta F(2, 110) = 9.83, p = .000$), which accounted for 15% of the variance, gender and Gambling accounted for a further 8.0% variance, $\Delta F(2, 108) = 5.53, p = .005$). Main effects were Gambling, $\beta = -.26, t(114) = -2.99, p = .004$, and gender, $\beta = -.11, t(114) = -1.23, p = .22$. The gender X Gambling interaction accounted for an additional 0.2% variance, $\Delta F(1, 107) = .29, p = .60$) and was not significant. Those low in executive function (Gambling) displayed more aggression. Plotting the simple slopes shows the main effect for Gambling (see Figure 3). The slope for males reached significance, $b = -.14, t(114) = -2.23, p = .03$, whereas the slope for females did not, $b = -.10$, $t(114) = -1.50, p = .14$.

In summary, Card Sort and Gambling demonstrated a moderation of aggressive responding when provoked, however, simple slope analyses revealed that this was only the case for males. The third measure of EF (Trail B) showed only a meaningful trend for males. At best only the Gambling task showed a trend for females. Card Sort and Gambling appear to be relatively independent moderators of aggression; however, Trail B seems to not add anything unique.

**Executive Function – Total Score.** Recognizing the low correlation between the measures of EF and given the common practice of conjoining measures of EF that tap
orthogonal facets (Godlaski & Giancola, 2009), the three measures of EF used in the current study were standardized and summed together to create a total score. Gender and EF-Total accounted for 15% variance ($\Delta F(2, 107) = 5.69, p = .004$) over and above ratings of suspicion, $\Delta F(2, 109) = 9.54, p = .000$). Main effects for EF-Total were, $\beta = -.27, t(114) = -3.13, p = .002$, and gender were, $\beta = -.12, t(114) = -1.36, p = .18$. Hierarchical regression indicated a trend for the gender X EF-Total interaction, $\Delta F(1, 106) = 2.87, p = .09, \beta = .14, t(114) = 1.69, p = .09$. Examining simple slopes and consistent with analyses above, both simple slopes were negative, suggesting moderation; however, only the slope for males reached significance, $b = -.14, t(114) = -2.23, p = .03$, whereas the slope for females did not, $b = -.10, t(114) = -1.50, p = .14$ (see Figure 4).

**Simultaneous Regression Analyses.** Given that the high degree of consensus in the above analyses in favour of EF moderating aggression, at least for males, a stepwise multiple regression analysis was conducted to determine the relative importance of each EF measure in predicting aggressive behaviour. Of particular interest was the degree of comparative predictability of “cool” versus “hot” EF. Controlling for suspicion in step 1 and splitting the file by gender, measures of EF as a block accounted for an additional 21% of the variance for males and only 3.3% of the variance for females (See Table 2). After simultaneously controlling for the other measures of EF, the strongest predictor for both males and females was the hot EF Gambling task, although the relationship reached significance only for males. These findings are consistent with individual analyses reported above.

**Discussion**

The prototypic instance of overt aggression is one in which the antecedent stimulus is a provocation (Anderson & Bushman, 2002; Berkowitz 1993). However, not all provocation leads to aggression. According to the integrative framework of Anderson and Bushman’s General Aggression Model (2002), person (e.g., personality traits) and situational (e.g., provocation) factors contribute to individual differences in aggressive responding. Studies have shown that executive functioning (EF) deficits are one type of individual difference factor that have been shown to moderate aggressive behaviour (e.g., Morgan & Lilienfeld, 2000). However, the majority of research on aggression has focused only on “cool” cognitively-based EF, whereas much less research has examined the relationship between aggression and “hot” emotionally-based EF. Results of the current study replicated previous findings supporting the hypothesis that
individuals with low EF are more aggressive than individuals with high EF. This was true for both “cool” and “hot” EF, however findings also revealed that the EF-aggression model was mostly significant for males but not females.

First, confirming the basic lab aggression paradigm and consistent with previous research (Bushman & Baumeister, 1998; 2009), participants in the provocation condition demonstrated more aggression by blasting their ostensive partner with higher levels of white noise than did participants in the praise condition. Consonant with their behavior, participants also reported significantly greater feelings of offense, insult, and anger in the provocation condition as compared to the praise condition. Below is a discussion of support for a component construct of EF, followed by a discussion of the moderation effects of “cool” and “hot” EF.

Executive Functioning as a Unitary or Component Construct

To the question of the potential unitary or component/fractionate nature of EF, findings revealed that the two measures of “cool” EF (i.e. Card Sort and Trail B) were significantly correlated, however neither measure of “cool” EF was related to “hot” EF (i.e., Gambling). Results of this study are consistent with a multifaceted view of EF, including a distinction between “cool” and “hot” EF. The current study is consistent with the literature which has largely found EF to be a multi-faceted construct with consistently low correlations among tests all purporting to measure EF (Miyake et al., 2000). The moderate correlation found between the two measures of “cool” EF suggests that while the two measures are overlapping, the specific aspects of EF that each instrument taps into are different.

Most studies of “hot” EF fail to include the correlation of the Gambling task with other EF measures. Of the few that exist, present results are consistent with research indicating no correlation between Gambling and Card Sort, for example, in nonclinical (Lehto & Elorinne, 2003) and clinical (Ernst et al., 2003) samples. The lack of correlation indicates that the executive processes involved in the measurement of “cool” and “hot” EF are distinct. The measurement of EF remains incomplete without assessing the additional motivational or affective component. As discussed below, taking into account both facets of EF is necessary to adequately assess behaviours such as aggression.

Cool and Hot Executive Functioning as Moderators of Aggression

Replicating previous research, the current study found that those who are lower in EF demonstrate more physically aggressive behaviour following provocation (see Figure 1;
Godlaski, & Giancola, 2009; Hoaken et al., 2003). Results indicated a moderating relation between one of the measures of “cool” EF (i.e. Card Sort) and aggression and a trend toward moderation with the other (i.e. Trail B). These findings support the growing body of literature that EF deficits are associated with increased aggression (e.g. Easton et al., 2008; Giancola & Mezzich, 2000; Lau et al., 1995; Lueger & Gill, 1990; Muira, 2009; Serper, Beech, Harvey, & Dill, 2008; Stanford et al., 1997; Valliant et al., 1999). Aggressive individuals tend to be more concrete in their thinking and have poorer abilities to generate alternative responses, leading to difficulty formulating flexible plans to achieve goals. Cognitive inflexibility, combined with an inability to inhibit behaviour and a reduced consideration of the consequences of maladaptive actions results in a proclivity for aggression.

Whereas the Card Sort measures cognitive flexibility with rule change (i.e., set shifting or the ability to monitor outcomes and incorporate shifting feedback to regulate behaviour towards the achievement of goals), and performance was based on perseveration, or failure to use feedback to correct responses, the Trail B measures cognitive flexibility and sequential processing, and performance was based on speed of completion (Heaton et al., 1993; Reitan, 1958). The finding that Trail B did not result in statistical significance is consistent with results of Lueger and Gill (1990), who sampled adolescents with and without Conduct Disorder, and Stanford Greve, and Gerstle (1997), who examined aggression in college students, in which performance on the Trail B did not significantly correlate with aggression. It may be that the current sample size produced insufficient power to result in significance. Alternatively, The Trail B may not be sufficiently sensitive to detect differences in levels of EF deficit in normal populations. Indeed, Lange and colleagues (2005) found a linear relationship between traumatic injury severity and performance on the Trail B. Time to completion increased with severity of brain injury, which suggests that individuals from nonclinical samples would demonstrate less disparate performance times. On the other hand, the specific executive processes assessed by the Trail B may not be as closely related to aggressive responding. Kortte, Horner, and Windham (2010) argued that although the Card Sort and the Trail B are moderately correlated and both measures of cognitive flexibility, the “hallmark cognitive process” underlying the Trail B is not cognitive flexibility but an unknown factor (p. 108). A review by Sanchez-Cubillo et al. (2009), which examined the processes that underlie different scores of the Trail Making Test, found the direct Trail B score to measure working memory over task-switching ability, or cognitive
flexibility. Alternatively, these conflicting results may be due to the significant difference in the nature of the two measures. Whereas the Card Sort requires learning to shift to a new category of four options over numerous trials, the rules for which change throughout the task, the much shorter Trail B involves shifting between two categories using the same rule throughout. Thus, the Card Sort is much more complex, and the demands may represent a more accurate assessment of EF. Clearly, more research is required to better understand specifically what underlying processes each of these instruments measure and how these processes are associated with aggression.

Research on “hot” EF remains in its infancy, and studies that simultaneously include both facets of EF are few (Séguin & Zelazo, 2005). Results of the current study indicated a moderating relation between the measure of “hot” EF (i.e. Gambling Task) and aggression. The Gambling task is designed to imitate balancing the rewards and penalties of real-life decision-making, and performance is associated with emotional processing (Bechara et al., 1994; Buelow & Suhr, 2009). Results are consistent with research by Best, Williams, and Coccaro (2002) who found that patients with an impulsive aggressive disorder chose significantly fewer cards from advantageous decks than normal controls. Performance on the Gambling task has been found to be significantly poorer in inmates with psychopathic traits (Mitchell et al., 2002), individuals with a history of substance use disorder (Barry & Petry, 2008), those diagnosed with antisocial personality disorder (Mazas et al., 2000), and violent as compared to nonviolent suicide attempters (Jollant et al., 2005). Although Miura (2009) found no significant difference on selection of cards between violent and nonviolent adolescents with conduct disorder, that study was limited by the use of a specific population with a confounding disorder. In general, individuals with poor performance are directed by immediate outcomes, regardless of whether they are negative. Thus, present findings suggest that aggressive individuals have more difficulty making decisions involving immediate rewards and long-term consequences. It may be that they are less able to learn from the consequences of maladaptive behaviour, such as aggression, because they focus on the immediate reward of retaliation at the expense of the long-term benefits of non-aggressive behaviour.

One of the main aims of this study was to compare “cool” and “hot” EF as moderators of aggression, and results revealed that the Gambling task was the strongest predictor of all EF measures. These results are consistent with aggression typically being an emotionally-laden act.
Consistent with Giancola’s model (1995), deficits in emotion-regulation can lead to the expression of negative cognitions and affects, such as frustration. Frustration and anger, frequent precursors to aggressive behaviour, are more affectively-based than cognitively-based constructs (Anderson and Bushman, 2002; Berkowitz, 1993).

Current findings support the literature that measures of both “cool” and “hot” EF moderate aggression. Taken together, individuals more prone to aggressive response have deficits in cognitive flexibility, behavioural inhibition, and/or emotion regulation, especially in the face of provocation.

Executive Function Moderates Aggression, but Only for Males

The majority of studies on EF and aggression have used male only samples (e.g. Easton et al., 2008; Lau et al., 1995; Lueger & Gill, 1990; Muira, 2009; Valliant et al., 1999) or used predominately male samples and did not examine differential results based on gender (e.g. Best et al., 2002; Ernst et al., 2003; Serper et al., 2008). Hoaken et al. (2003) examined gender, but did not discuss the implications of their results. The current study sought explicitly to examine gender differences in moderation effects, with the finding that results for one of the measures of “cool” EF and the measure of “hot” EF are only applicable to males. Also, the other measure of “cool” EF showed a meaningful, but not quite significant, relation for males.

Nevertheless, present findings are consistent with the few studies that do examine gender differences in the EF-aggression relationship. In 2006, Giancola, Roth, and Parrott (2006) found that EF mediated the relationship between difficult temperament and intoxicated aggression for males, but not females, despite comparable EF performance. Later, Godlaski and Giancola (2009) found that the EF-aggression relation was mediated by irritability, but only for intoxicated men. They conclude that men are significantly more prone to aggressive behaviour than women when they experience a negative state. The gender difference in EF on aggression is visible even at extreme levels of antisocial behaviour. For example, Daoust, Loper, Magaletta, and Diamond (2006) found a relation between aggression and neuropsychological dysfunction in female federal offenders. However, the authors note that results differed from those found with male inmates. Whereas female inmates’ neuropsychological scores were comparable to normal controls, a difference is typically found between male inmates’ performance and controls. Although the significant relation they found in females is in contrast to the present study, it may be that the EF-aggression relation is more notable in females with a general propensity for
maladaptive behaviour than in females from normal populations. Alternatively, the inconsistency may be due to Daoust et al. having used self-report measures, whereas the current study used clinical measure of EF and an experimental measure of aggression.

Taken together, current results suggest that males with poor EF become focused on the immediate reward of aggression at the expense of the long-term benefits of socially appropriate behaviour. This focus is narrowed by an inability to inhibit behaviour and an inability to generate solutions other than aggression. Females, in contrast, do not resort to such levels of aggression despite comparable EF and provocation. It may be that females are able to generate solutions other than aggression in the face of provocation, or that they can better inhibit their behaviour or regulate their emotions in such circumstances. Given that females are much less aggressive than males, perhaps their level of aggression is insufficient for moderation. On the other hand, results of meta-analyses consistently demonstrate that males and females display aggression differently (e.g. Archer, 2004; Bettencourt & Miller, 1996). Whereas males use physical aggression, females are more likely to use relational or social aggression. EF may moderate those types of aggression in females more so than physical aggression. Future research should consider that EF influences aggressive response differently in males and females.

**Strengths and Limitations**

The strengths of the current study rest in the experimental manipulation. The majority of previous research has used clinical samples, such as violent inmates or in- and outpatients with known neuropsychological difficulties. While these studies support the association between EF and aggression, investigating how EF moderates aggression in a controlled environment with random selection of nonclinical individuals is also of significant value. In their review, Hawkins and Trobst (2000) conclude that evidence of the relationship between EF deficits and aggression in non-clinical populations speaks to the sensitivity of the relationship.

The results of the present investigation give credence to the validity of the study manipulation, and highlight areas in need of future research. Although the present study controlled for levels of suspicion, this study did not take into account the influence of other possible confounding factors associated with aggression. Future research should control for factors such as intelligence, which is often considered as protective against the development of aggression (Kandel et al., 1988), and specific diagnoses, such as substance abuse and Attention
Deficit Hyperactivity Disorder, which are both significantly correlated with antisocial behaviour, including aggression (Morgan & Lilienfield, 2000).

Another limitation of the current study is the issue of task impurity in the measurement of EF. As a result of the complexity of the EF construct, assessment of EF processes necessarily integrates non-executive factors, such as memory and intelligence (Zelazo & Müller, 2002), and language, motor, and perceptual skills (Anderson et al., 2001). Furthermore, because different aspects of EF are part of a complex inter-related system, it is difficult to distinguish exactly which processes are being measured with specific EF tasks. For instance, although research supports a “cool” and “hot” dichotomy, these processes are not mutually exclusive, but remain part of the same EF system; measurement in one area will inevitably be related to measurement in the other (Zelazo & Müller, 2002). Until pure EF tasks are available, it is important to be cognizant of the influence non-EF processes can have on current assessment instruments. Deficits in EF and non-EF processes can both result in poor performance on EF tasks. Thus, assessment of EF should take into account the non-EF processes incorporated in specific tasks (Anderson et al., 2001; Jurado & Rosselli, 2007).

Conclusion

Given the link between executive function and aggression, this research increases our theoretical understanding of the courses through which aggression and violence develop by helping to clarify this connection. The current investigation demonstrates that aggression increases with provocation and with lower executive functioning; however, the moderation of EF may only hold for males. In order to understand the relationship between EF and aggression more completely, further (and more longitudinal) studies are required. Of particular interest would be further examination of gender issues in the EF-aggression relation. An examination of the associations among the multiple facets of EF and different types of aggression (i.e. proactive) would also contribute significantly to the literature. Most importantly, however, this study provides support for the hypothesis that those with poorer executive functioning are more physically aggressive when provoked, especially males. Overall, findings support a multifaceted conceptualization of EF, particularly with regards to the distinction between “cool” and “hot” EF. While hot EF may represent the most elusive facet of a still poorly defined construct, present findings highlight the importance of including measures of “hot” EF in the assessment process. The completion of more comprehensive assessments will help to identify those at risk of
aggression and violence, which in turn could lead to the development of more efficacious methods of prevention and intervention.
Table 1

*Intercorrelations Among Measures*

<table>
<thead>
<tr>
<th></th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
<th>5.</th>
<th>6.</th>
<th>7.(t/m/f)</th>
<th>M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gender</td>
<td>.02</td>
<td>-.05</td>
<td>-.06</td>
<td>-.13⁺</td>
<td>.01</td>
<td>-.07</td>
<td></td>
</tr>
<tr>
<td>2. Card Sort</td>
<td>.31**</td>
<td>-.03</td>
<td>-.02</td>
<td>-.02</td>
<td>.15* / .37** / .06</td>
<td>17.30 (7.04)</td>
<td></td>
</tr>
<tr>
<td>3. Trail B</td>
<td>-.04</td>
<td>-.03</td>
<td>-.10</td>
<td>-.14 / .24 / .04</td>
<td>46.46 (19.87)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Gambling</td>
<td>.06</td>
<td>.09</td>
<td>-.31**/- .38**/- .23</td>
<td>-2.41 (30.66)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Suspicion — self-report</td>
<td>.56**</td>
<td>-.36**</td>
<td></td>
<td>3.93 (3.92)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Suspicion — research assistant</td>
<td></td>
<td>-.35**</td>
<td></td>
<td>1.30 (.71)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Aggression</td>
<td></td>
<td></td>
<td></td>
<td>2.65 (14.65)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Notes.*  
⁺p < .10, *p < .05, **p < .01, ***p < .001 (N = 224)  
t = total; m = male; f = female  
Correlations with aggression are in the provocation condition (N = 115)
Table 2

*Simultaneous Regression of Executive Functioning Measures Predicting Aggression by Gender after Controlling for Suspicion*

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th></th>
<th></th>
<th></th>
<th>Females</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ΔR²</td>
<td>ΔF</td>
<td>β</td>
<td>Partial r</td>
<td>t</td>
<td>ΔR²</td>
<td>ΔF</td>
<td>β</td>
</tr>
<tr>
<td>Card Sort</td>
<td>.21</td>
<td>4.00*</td>
<td>-.28</td>
<td>-.29</td>
<td>-1.85†</td>
<td>.03</td>
<td>.87</td>
<td>-.08</td>
</tr>
<tr>
<td>Trail B</td>
<td>-.03</td>
<td>-.04</td>
<td>-.22</td>
<td></td>
<td></td>
<td>-.00</td>
<td>-.00</td>
<td>-.00</td>
</tr>
<tr>
<td>Gambling</td>
<td>-.28</td>
<td>-.31</td>
<td>-1.98*</td>
<td></td>
<td></td>
<td>-.17</td>
<td>-.18</td>
<td>-1.47</td>
</tr>
</tbody>
</table>

*Notes.* † p < .10, * p ≤ .05
Figure 1. Executive Function (EF-Card Sort) as a Moderator of Aggression for Males and Females.
Figure 2. Executive Function (EF-Trail B) as a Moderator of Aggression for Males and Females.
Figure 3. Executive Function (EF-Gambling Task) as a Moderator of Aggression for Males and Females.
Figure 4. Executive Function (EF-Total Score) as a Moderator of Aggression for Males and Females.
References


