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Exploring the differential associations between components of executive functioning and reactive and proactive aggression

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ABSTRACT

Objective: A large body of literature confirms the importance of executive functioning (EF) in the explanation of aggressive and antisocial behaviors. However, the common and specific associations between subtypes of aggression, such as reactive (RA), proactive aggression (PA), and EF are unclear. The current study explored the nuanced associations between components of EF and subtypes of aggression, using a latent variable approach.

Method: Participants were 384 racially diverse undergraduate students (ages 18–52 years) who completed a self-report measure of RA and PA, and traditional neuropsychological tasks of EF. The appropriateness of using a nested bifactor model of EF was confirmed, and this bifactor model of EF was then used to examine the specific associations between components of EF and RA and PA. Results: Results revealed that components of EF are differentially associated with RA and PA. Specifically, impulsive, provoked aggression (i.e., RA) was associated with lower levels of goal-oriented inhibition and higher levels of flexibility, whereas planned, goal-oriented aggression (i.e., PA) was associated with higher levels of working memory. Conclusions: Findings from the current study underscore the importance of considering the multidimensional nature of EF, as well as the heterogeneity within aggression, rather than considering either construct as a single monolithic construct. The current study suggests that potentially unique brain-based pathways from aspects of EF to subtypes of aggression may exist, and points toward potential avenues through which to intervene.
and defensive response to a provocation. In contrast, PA, rooted in social learning theory (e.g., Bandura, 1978), is a premeditated, planned, and deliberate act that is committed as a means to achieve a secondary goal. These related, but separable constructs (e.g., Poulin & Boivin, 2000; Raine et al., 2006) are highly correlated (Poulin & Boivin, 2000), although they do exhibit differential correlates (e.g., Brendgen, Vitaro, Tremblay, & Lavoie, 2001; Connor, Steingard, Cunningham, Anderson, & Melonni, 2004; Hecht, Berg, Lilenfeld, & Latzman, 2016; Latzman & Vaidya, 2013; Latzman, Vaidya, Clark, & Watson, 2011) and relate to different outcomes (Fite, Raine, Stouthamer-Loeber, Loeber, & Pardini, 2010). Moreover, when overlapping variance between RA and PA is statistically accounted for through the use of residual scores, their associations with external correlates appear to become even more distinct (e.g., Cima & Raine, 2009; Hecht et al., 2016; Hecht & Latzman, 2015). Such differences support the distinction between RA and PA, and are indicative of potentially different etiological pathways underlying these subtypes of aggression (Crick & Dodge, 1996; Latzman et al., 2011; Raine et al., 2006).

Surprisingly, however, few studies have examined the contribution of more basic neurocognitive mechanisms (i.e., EF) in the explanation of these subtypes of aggression.

Executive functioning and aggression

Executive functioning is a broad construct that is often recognized as important for self-regulation (Gyurak et al., 2009; Patrick, Blair, & Maggs, 2008) in the service of organized, goal-oriented behavior (Friedman et al., 2008; McCabe, Roediger, McDaniel, Balota, & Hambrick, 2010; Miyake et al., 2000). Deficits in EF have repeatedly been associated with aggression across cross-sectional (e.g., Giancola, 1995; Séguin, 2009) and meta-analytic studies (e.g., Morgan & Lilenfeld, 2000; Ogilvie et al., 2011). Although a large literature associates aggression with deficits in frontal lobe functioning and EF (see Brower & Price, 2001, for a review), a smaller body of literature suggests that some antisocial (e.g., theft; Barker et al., 2007) and aggressive behaviors (e.g., planned murders; Raine et al., 1998) are associated with higher EF. Thus, it appears that some antisocial and aggressive acts may require higher levels of certain aspects of EF, such as planning and conceptual flexibility, whereas others are associated with lower levels of EF. Overall, although the above-reviewed literature indicates that aggression is broadly associated with deficits in EF, such broad classifications of aggression may mask important developmental differences between specific subtypes of aggression, and thus may impede the identification of their underlying mechanisms (Barker et al., 2007).

Self-regulatory abilities and reactive and proactive aggression

Important differences have been found between RA and PA in relation to cognitive and self-regulatory abilities. For instance, several studies have linked RA to impairments in executive functioning (e.g., Ellis, Weiss, & Lochman, 2009; Giancola, Martin, Tarter, Pelham, & Moss, 1996; Stanford, Greve, & Gerstle, 1997) and particularly inattention (Dodge, Lochman, Harnish, Bates, & Pettit, 1997; Vitaro, Brendgen, & Tremblay, 2002), low self-control (Latzman & Vaidya, 2013; Latzman et al., 2011) or higher levels of impulsivity (Dodge et al., 1997; Miller & Lynam, 2006), principally impulsivity during periods of negative affect (Hecht & Latzman, 2015), and poor response inhibition (Feilhauer, Cima, Korebrtis, & Kunert, 2012).

Few studies have considered the role of specific cognitive processes in PA; however, it appears that PA may not be associated with the same executive functioning impairments as RA (Ellis et al., 2009) and may be associated with, for example, better response inhibition (Feilhauer et al., 2012). Further, PA is less strongly associated with (Latzman & Vaidya, 2013) or not associated with (Latzman et al., 2011) lower levels of self-control, although this finding is not unequivocal, as impulsivity-related psychopathic personality traits have been found to be more strongly associated with PA than RA (Hecht et al., 2016). Proactively aggressive children also do not display the same difficulties with attention exhibited by those who engage in RA or a combination of RA and PA, and informants rate PA children lower on impulsivity than RA children (Dodge et al., 1997). All told, the extant literature highlights the importance of self-regulatory abilities, such as EF, in the explanation of RA and PA, but indicates that RA and PA may result from different underlying cognitive processes.

Surprisingly, however, few studies have explicitly examined the specific associations between EF and RA and PA. Among those that have, for example, impulsive-aggression has been found to exhibit impairments across various scores from complex EF tasks, indicating problems with impulsive control and verbal strategic processing, (Stanford et al., 1997) as well as organizing verbal information on tasks with increasing executive demands (Villemare-Pittman, Stanford, & Greve, 2003). Overall, these studies indicate that RA is associated with lower levels of EF; however, the way in
which EF may relate to both impulsive as well as planned acts of aggression remains unanswered. Moreover, from this literature it is unclear precisely which components of EF are most relevant to RA. One reason for this is that single scores from complex or broad neuropsychological measures involving multiple EF processes are susceptible to the task impurity problem, described in more detail below; similarly, aggregating multiple tasks into a single factor of EF mask important differential associations between components of EF and RA/PA.

**EF as a multidimensional construct**

EF is a complex construct that is difficult to define (Jurado & Rosselli, 2007) and to measure (Miyake & Friedman, 2012). Tasks designed to measure EF necessarily involve the use of multiple cognitive processes, including non-EF processes such as perception, attention, and memory. As such, scores from EF tasks are confounded by variance attributable to multiple processes, making it difficult to isolate that attributable to the specific EF of interest (e.g., Miyake & Friedman, 2012; Miyake et al., 2000; Washburn, Latzman, Schwartz, & Bramlett, 2015). Recent efforts by Miyake and colleagues (Miyake & Friedman, 2012; Miyake et al., 2000), as well as others (e.g., Latzman & Markon, 2010; Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003), have used factor-analytic methods to overcome these problems. Using this approach across various samples and tasks, researchers have demonstrated considerable empirical support for a three-factor model of EF (Friedman, Miyake, Robinson, & Hewitt, 2010; Latzman & Markon, 2010; Miyake & Friedman, 2012; Miyake et al., 2000; Rose, Feldman, & Jankowski, 2011; Vaughan & Giovanelli, 2010). These three separable, yet related, components have been termed Inhibition (Latzman & Markon, 2010; Lehto et al., 2003; Miyake et al., 2000), Monitoring (Latzman & Markon, 2010; also referred to as “Working Memory” by Lehto et al., 2003; and “Updating” by Miyake et al., 2000), and Conceptual Flexibility (Latzman & Markon, 2010; also termed “Shifting” by Lehto et al., 2003; Miyake et al., 2000). The Inhibition component reflects an individual’s ability to control or inhibit dominant or automatic responses to stimuli; Monitoring involves the tracking and appraisal of incoming task information as well as the updating of information in working memory if appropriate; and Conceptual Flexibility involves shifting between tasks and performing new tasks while dealing with proactive interference from the previous task.

Emerging research suggests that a nested model may better capture the separable but related structure among factors of EF (e.g., Friedman et al., 2008, 2011). Specifically, Friedman and colleagues demonstrated that individual differences in inhibitory abilities are entirely explained by the variance that is common across all EF tasks. In this bifactor model, the unity of EF is represented by a “Common EF” factor encompassing the shared variance across all EF tasks, and the diversity of EF is represented by “Updating-specific” and “Shifting-specific” factors, each of which encompass the variance unique to their respective components of EF. Although no studies to date have tested this model using traditional neuropsychology-based tasks of EF, the framework has received considerable support across various independent samples using computerized EF tasks (for a review, see Miyake & Friedman, 2012) and is increasingly utilized to disentangle EF’s association with external correlates (e.g., personality; Fleming, Heintzelman, & Bartholow, 2016).

With regard to aggression, although this bifactor model was not used specifically, one study to date has examined both RA and PA in relation to three similar components of EF in a sample of elementary-school boys (Ellis et al., 2009). The authors utilized performance on three tasks as individual indicators of aspects of EF: cognitive flexibility, planning, and response inhibition. RA was positively associated with response inhibition difficulties, but not significantly associated with planning or conceptual flexibility; however, significant interactions were found, such that individuals with higher levels of social information processing deficits exhibited stronger associations between response inhibition and RA, as well as planning and RA. Whereas no main effects were found between PA and any of the EF variables, a significant interaction emerged such that individuals with higher levels of social information processing deficits exhibited a stronger negative association between planning deficits and PA. These findings indicate that EF deficits, and particularly inhibition, may be associated with RA, but that PA appears to be unrelated or possibly negatively related to specific deficiencies in EF (Ellis et al., 2009).

Nevertheless, the authors utilized the Wisconsin Card Sorting Test and Tower of Hanoi as indicators of EF, and these tasks are susceptible to the task impurity problem described previously. Further, by running separate hierarchical regression models for each component of EF, shared variance among components of EF was left unaccounted for. As reviewed above, components of EF are related yet separable (as are RA and
PA); therefore, accounting for the unity and diversity of EF is vital to understanding the unique relationships between EF and RA/PA.

Current study

The current study explored the specific associations between components of EF (i.e., its unity and diversity) and subtypes of aggression (i.e., RA and PA). Consistent with previous research (i.e., Cima & Raine, 2009; Hecht et al., 2016; Hecht & Latzman, 2015), in bivariate analyses both raw and residual RA/PA scores were used to isolate “pure” RA and PA independent of each other. Similarly, using structural equation modeling, overlapping variance between RA/PA was taken into account.

In addition to this more nuanced investigation of RA and PA, the current study further improves upon the previous literature through the use of a nested, bifactor model of EF using traditional neuropsychology-based indicators of EF. By including all variables simultaneously in structural modeling, the current study examined the specific associations between latent components of EF and RA/PA, while accounting for shared variance between RA/PA.

Consistent with Friedman and colleagues (2008, 2011; Miyake & Friedman, 2012), it was expected that the nested, bifactor model of EF would fit the data well. The hypothesized nested model consists of three factors: a “Common EF” factor, accounting for shared variance across EF tasks and thus encompassing variance related to Inhibition; a “Monitoring-specific” factor, accounting for variance unique to scores tapping the ability to track and appraise incoming task information and update information in working memory appropriately; and a “Conceptual Flexibility-specific” factor, accounting for variance unique to scores tapping the ability to shift between tasks. Because RA is an impulsive response to provocation (e.g., Berkowitz, 1993), and research indicates it is associated with decreased levels of inhibition (e.g., Ellis et al., 2009), it was hypothesized that RA would be uniquely negatively associated with the Common EF factor. Given that the two studies that suggest planned or deliberate acts may be associated with increased EF (e.g., theft in Barker et al., 2007; and premeditated murder in Raine et al., 1998), it was tentatively hypothesized that PA would be uniquely positively associated with higher levels of both Monitoring-specific and Conceptual Flexibility-specific EF, as PA theoretically requires the ability to maintain and update strategies in the service of goal attainment.

Method

Participants

Data were drawn from a racially diverse sample of 384 undergraduate participants, aged 18–52 years ($M_{age} = 20.9, SD = 4.9$; 57% female), who participated in a larger study of cognitive and personality factors contributing to individual differences in behavior among college students in partial fulfillment of a research exposure requirement for a psychology course at a large public Southeastern university (see Hecht & Latzman, 2015, in which RA/PA was examined in relation to facets of self-reported impulsivity). Of the participants, 45.6% self-identified as African-American/Black, 30.5% as White, 11.2% as Asian/Asian-American, 8.1% as other. All procedures were approved by the university’s Institutional Review Board. Participants enrolled in the study through a university approved computerized participant tracking system. Upon arrival to the laboratory, informed consent was obtained, and then participants completed the following measures.

Measures

Delis–Kaplan Executive Function System (D-KEFS)

The Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001) is a standardized assessment of executive function. The D-KEFS was standardized on a nationally representative, stratified sample of nonclinical children, adolescents, and adults, ages 8–89 years. The D-KEFS has research support for its general validity and internal consistency reliability (Delis, Kramer, Kaplan, & Holdnack, 2004), as well as test–retest reliability (Homack, Lee, & Riccio, 2005).

Factor analytic work (Latzman & Markon, 2010) has found that D-KEFS individual achievement scores can be reduced to three components: Conceptual Flexibility, Monitoring, and Inhibition. These three empirically derived aspects of EF have been shown to be differentially associated with other outcomes of interest (e.g., academic achievement; Latzman, Elkovitch, Young, & Clark, 2010). Based on this previous work, the following D-KEFS tasks were chosen as they have been shown to evidence the highest loadings on EF components: Trail Making Test (TMT), Verbal Fluency Test, Color–Word Interference Test (CW), and the Sorting Test (see Latzman & Markon, 2010, for a description of the tasks and their respective loadings). Specifically, Conceptual Flexibility is best reflected by all three scores from the Sorting Test: free sort, free sort description, and sort recognition; Monitoring is reflected by the two category switching scores from the Verbal Fluency tests; and Inhibition is reflected by the inhibition and inhibition/switching scores from the Color–Word Test in addition to the
Trail Making Test. Given that these tasks evidenced the highest factor loadings, it was assumed that the tasks would adequately measure the unity and diversity of EF in the current study. Standard scores from each task were included in analyses.

**Reactive–Proactive Aggression Questionnaire**
The Reactive–Proactive Aggression Questionnaire (RPQ; Raine et al., 2006) is a 23-item measure with two scales: Reactive Aggression (RA) and Proactive Aggression (PA). Participants respond to items using a 3-point scale (never; sometimes; often) to indicate how often they have engaged in various reactively aggressive and proactively aggressive behaviors. Each item is rated as 0 (never), 1 (sometimes), or 2 (often) for frequency of occurrence. The RPQ demonstrates adequate reliability, with internal consistencies ranging from .86 for PA to .84 for RA (Raine et al., 2006). As reported previously (Hecht & Latzman, 2015), in the current sample, internal consistencies were .82 for RA and .81 for PA.

**Analyses**
In addition to raw (original) RA and PA scores, because RA and PA are often highly correlated (Poulin & Boivin, 2000), and consistent with previous research (i.e., Cima & Raine, 2009; Hecht et al., 2016; Hecht & Latzman, 2015), residualized RA and PA scores were saved to index “pure” RA and PA independent of each other. Specifically, RA was regressed on PA, and the standardized residual was saved, and vice versa; and zero-order correlations between D-KEFS scaled scores and RA/PA were calculated.

A nested bifactor measurement model was then specified to confirm that the nested, bifactor model of EF fit the data well. All structural analyses were completed using Mplus 7 (Muthén & Muthén, 1998–2012). Consistent with previous factor-analytic work (i.e., Latzman & Markon, 2010), three components of EF were specified to fit the data (see Figure 1): Common-EF, Monitoring-specific-EF, and Conceptual Flexibility-specific EF. All eight D-KEFS scores were set to load on the Common EF factor. In addition, the two scores from the Verbal Fluency Task (Category Switching condition) were set to load on the Monitoring-specific factor, and the three scores from the Card Sorting Task (Free Sort and Sort Recognition conditions) were set to load on the Conceptual Flexibility-specific factor. Parcels were then created as indicators of RA and PA. This use of parcels rather than individual items results in fewer observed variables, thereby increasing power (Little, Cunningham, Shahar, & Widaman, 2002). RA and PA were each measured by three parcels computed from the average of multiple items from their respective scales. To ensure that parcels were balanced indicators of their respective construct, item–total correlations were first conducted between items from each scale and the respective total score. Item to construct balancing was used to select items for each parcel so that low, moderate, and high indicators were equally represented.

![Figure 1. Measurement model depicting nested, bifactor model of executive functioning (EF). Note. N = 384. \( \chi^2(17) = 35.33, p < .01; \) standardized root mean square residual (SRMR) = .04; comparative fit index (CFI) = .99; root mean square error of approximation (RMSEA) = .05. Latent factors of EF are indicated by standardized Delis–Kaplan Executive Function System (D-KEFS) scores. Numbers on paths between indicators and EF components represent standardized factor loadings; all factor loadings are significant. Numbers on arrows pointing to each indicator represent standardized residual variances. TMT 4 = Trail Making Test, Condition 4; CW 3 = Color–Word Interference Task, Condition 3; CW 4 = Color–Word Interference Task, Condition 4; VF CS = Verbal Fluency, Category Switching score; VF CSA = Verbal Fluency, Category Switching accuracy; ST 1 CC = Card Sorting Test, confirmed correct sorts; ST 1 FS = Card Sorting Test, free sort description score; ST 2 SD = Card Sorting Test sort recognition description score.](image-url)
across parcels (Little, Cunningham, Sharer, & Widaman, 2002). The resulting parcels each consisted of 2–3 items. Finally, a structural equation model (SEM) was then specified in which RA and PA were regressed on the components of EF from the nested, bifactor measurement model, as well as the demographic covariates of age, gender (dummy coded as female = 1, male = 0), and race (dummy coded as White = 1, non-White = 0).

**Results**

**Bivariate correlations**

Bivariate correlations between demographic variables, D-KEFS scaled scores, and both raw and residual RA/PA are shown in Table 1. Both raw and residual PA were significantly negatively associated with gender ($r = -0.23$, $p < 0.01$; $r = -0.25$, $p < 0.01$, respectively), indicating that being female was associated with lower levels of PA, whereas being male was associated with higher levels. No other significant associations emerged between RA/PA and demographic variables.

The pattern of correlations between D-KEFS scores and aggression was largely consistent for raw and residual RA/PA. Raw PA was not significantly associated with any of the D-KEFS variables, whereas raw RA was significantly negatively associated with both TMT Condition 4 and CW Condition 3 ($r = -0.13$, $p < 0.05$; $r = -0.24$, $p < 0.05$, respectively). Similarly, residual RA was again significantly negatively associated with both TMT Condition 4 and CW Condition 3 ($r = -0.10$, $p < 0.05$; $r = -0.15$, $p < 0.01$, respectively); whereas residual PA emerged as significantly positively associated with CW Condition 3 ($r = 0.29$, $p < 0.01$). Overall, correlations between the D-KEFS scores and RA/PA (both raw and residual) were quite low, indicating that each individual core accounted for very little variance in aggression.

**Nested bifactor model of EF**

Within the measurement model, all items loaded significantly on their respective factors (see Figure 1). Although the chi-square test of model fit was significant ($p < 0.01$), the remaining fit indices were favorable (standardized root mean square residual, SRMR <.10; comparative fit index, CFI >.95; root mean square error of approximation, RMSEA <.10; Kline, 2011), indicating that this model fit the data well. The magnitude of the factor loadings ranged from .23 to .76 for Common EF (with the highest factor loadings demonstrated by the two scores from the Color–Word Interference Task), .92–.94 for Monitoring-specific EF, and .56–.93 for Conceptual Flexibility-specific EF.

**Structural equation modeling**

As shown in Figure 1, the nested bifactor model fit the data well: $\chi^2 (102) = 231.45$, $p < .01$; SRMR = .07; RMSEA = .06. Only PA emerged as significantly associated with any of the covariates; specifically, PA was significantly negatively associated with gender ($\beta = -0.26$, $p < .01$) as well as race ($\beta = -0.21$, $p < .01$), indicating that being female and being white were both associated with lower levels of PA. Consistent with previous research (e.g., Hecht et al., 2016; Hecht & Latzman, 2015; Poulin & Boivin, 2000; Raine et al., 1996), latent RA and PA were significantly positively associated ($\beta = .72$, $p < .01$). As shown in Figure 2, PA was significantly explained by Monitoring ($\beta = .16$, $p < .01$), but was not explained by Inhibition ($\beta = -.01$, $p = .88$) or Conceptual Flexibility ($\beta = .09$, $p = .13$). RA was explained by Conceptual Flexibility ($\beta = .15$, $p < .02$) and Inhibition (although the association did not quite reach traditional levels of significance; $\beta = -.14$, $p = .05$), and was not significantly associated with Monitoring ($\beta = .04$, $p = .48$).

**Discussion**

A large body of literature confirms the importance of EF in the explanation of general aggression (e.g., Giancola, 1995; Morgan & Lilienfeld, 2000; Ogilvie et al., 2011; Séguin, 2009; Séguin & Zelazo, 2005); however, given a number of limitations, the precise nature of this association is poorly understood. The current study applied a bifactor model of EF to examine the specific associations between components of EF.
and RA and PA. Results revealed that components of EF are differentially associated with RA and PA, such that impulsive, provoked aggression is associated with lower levels of goal-oriented inhibition and higher levels of flexibility, whereas planned, goal-oriented aggression is associated with higher levels of working memory. Thus, findings from the current study underscore the importance of considering the multidimensional nature of EF as well as aggression when examining their associations with external constructs of interest.

**Nested, bifactor model of EF**

The current study extends the bifactor model of EF to the clinical neuropsychology domain, as it represents the first study to date to leverage traditional neuropsychology-based tasks of EF within this framework. Consistent with findings from the cognitive-psychology domain (e.g., Friedman et al., 2008, 2011; Miyake & Friedman, 2012), results from the current study revealed that a nested, bifactor model of EF is appropriate using traditional clinical neuropsychology data. In the current study, each D-KEFS task included variance that was both related and unrelated to the target component of EF, underscoring the strength of a latent variable approach that reduces the amount of error in each factor (Bollen, 2014). The advantage of this approach is also highlighted by the low bivariate correlations observed between specific D-KEFS scores and raw and residual RA/PA, which indicate that each individual D-KEFS task explains very little variance in RA and PA, underscoring the importance of using multiple task indicators to model the variance common across tasks as latent components of EF.

In terms of the unity of EF, factor loadings for the Common EF component ranged from .23 to .76; thus the contribution of each D-KEFS score was rather variable. The highest contribution was from Color–Word Interference performance, followed by Trail-Making. These tasks are heavily reliant on inhibitory processes, and are also the tasks evidencing the highest factor loadings on the Inhibition component of EF (Latzman & Markon, 2010). The Common EF variable thus largely reflects an ability to control or inhibit a prepotent response in the service of goal-oriented action, which...
also involves the ability to attend to incoming and potentially competing task information and shift action accordingly. This is in line with research utilizing computer-based tasks of EF (Friedman et al., 2008, 2011; Miyake & Friedman, 2012), in which the Common EF component is interpreted as encompassing the basic abilities required for all aspects of EF: the ability to actively maintain goals and use task-relevant information to engage inhibition as well as other lower-level processing toward successful goal completion (i.e., Munakata et al., 2011).

The diversity of EF is represented by the Monitoring- and Conceptual Flexibility-specific components of EF, which reflect variance from performance on their respective indicators after the variance attributable to Common EF has been removed. In the current study, Monitoring-specific EF largely encompassed variance that was specific to the ability to track and appraise incoming task information, filter information that is relevant to the task at hand, and update this information in working memory appropriately. This is largely consistent with Miyake and Friedman’s (2012) assertion based on computerized EF tasks, that this component is important for effectively filtering information and retrieving information from long-term storage. Finally, the Conceptual Flexibility-specific component encompassed variance specific to the ability to switch flexibly between tasks or mental sets. This overlaps with Miyake and Friedman’s (2012) understanding of this component as reflecting flexibility in transitioning between task sets.

**Associations between components of EF and RA/PA**

The latent variable approach utilized in the current study allowed for a more precise examination of the associations between components of EF and RA/PA than in previous studies, revealing specific associations between components of EF and RA and PA. Underscoring RA and PA’s important distinct correlates (e.g., Ellis et al., 2009; Fite et al., 2010; Kuin, Masthoff, Kramer, & Scherder, 2015; McAuliffe, Hubbard, Rubin, Morrow, & Dearing, 2006), these results suggest that RA and PA may arise from differing cognitive processes, with potentially unique neuroanatomical correlates.

The Common EF factor emerged as associated with RA at $p = .05$, and was not associated with PA. As this component represents EF variance common across all D-KEFS tasks, and represents goal-directed inhibitory abilities, it appears that increased levels of goal-directed inhibition may be associated with lower levels of impulsive, reactionary aggression. Although this association did not reach the traditional, dichotomous $p < .05$ level of significance, the implication is consistent with theoretical expectations. Given that a primary distinction between RA and PA is the degree of impulsivity underlying the behavior (Berkowitz, 1993; Dodge, 1991; Raine et al., 2006), it would follow that increased inhibitory abilities might contribute to decreased RA. Indeed, research has found RA to be associated with decreased inhibitory abilities, such as performance on a Stroop task (Ellis et al., 2009), and on the Wisconsin Card Sorting Test (WCST; Stanford et al., 1997), which has been shown to involve multiple component processes of EF including inhibition (Miyake et al., 2000). Moreover, Giancola et al. (1996) modeled a single latent EF factor from a variety of EF tasks, and found that it was negatively associated with RA; and more specifically, the tasks that evidenced positive factor loadings on the EF factor all required a high degree of goal-oriented inhibition (i.e., a maze, a vigilance, and a forbidden toy task). Taken together, results confirm the negative association between goal-directed inhibitory abilities and RA. Nevertheless, despite the fact that the current borderline significant results converge with evidence from the above-reviewed studies, it will be important for future research to both replicate and explicate this finding.

In addition to its negative association with Common EF, RA was significantly positively associated with the Conceptual Flexibility-specific component of EF. This is unexpected, as the ability to switch flexibly between tasks or mental sets would theoretically be unrelated or negatively associated with RA. There are several potential explanations for this surprising finding. First, the Conceptual Flexibility-specific component represents variance that is unique to performance on the three scores that comprise this component; in other words, it represents the variance that remains after Common EF (largely composed of goal-oriented inhibitory abilities) is removed. In contrast to inhibition, which can be thought of as rigidly resisting action, flexibility requires the ability to shift quickly, and to adjust to variability in task demands and changing contingencies. Once this inhibition-related variance is removed by the Common-EF component, the variance remaining in the Conceptual Flexibility-specific component may reflect flexibility in the absence of inhibition, or a liability toward reactivity. Indeed, RA has been conceptualized as emotionally driven (e.g., Berkowitz, 1993; Dodge, 1991), and research confirms its association with increased emotion dysregulation (Marsee & Frick, 2007; Shields & Cicchetti, 1998; Vitaro et al., 2002).

Research examining the association between Conceptual-Flexibility-specific abilities and
impulsivity-related constructs also helps to contextualize this surprising positive association. Specifically, Friedman and colleagues (2007) demonstrated that shifting abilities were positively associated with attention problems throughout adolescence. Similarly, the ability to shift attention has also been associated with decreased levels of response inhibition (Jones, Rothbart, & Posner, 2003). Moreover, in a longitudinal study, Friedman et al. (2011) revealed that youth with higher levels of self-restraint evidenced increased levels of Common-EF and decreased levels of Conceptual Flexibility-specific EF two years later. Taken together, it appears that common EF and shifting-specific abilities sometimes evidence surprising opposing patterns of associations with external constructs (Miya\textcolor{red}{k}e & Friedman, 2012), and particularly those related to behavioral control (Herd, Hazy, Chatham, Brant, & Friedman, 2014). Indeed, it has been theorized that goal-oriented action is regulated by opposing constraining forces (Goschke, 2000): Whereas goal completion requires stability in maintaining that goal (e.g., inhibition), it also requires an ability to adjust strategy according to changing demands (e.g., flexibility). Stated otherwise, successfully completing a task requiring high levels of Conceptual Flexibility-specific EF involves simultaneously carrying out two opposing processes—inhibiting the previous mental set while also holding it in mind and engaging a new task set (Davidson, Amso, Anderson, & Diamond, 2006). The decreased inhibition inherent in RA may allow for increased flexibility, which could help to explain the positive association between Conceptual Flexibility-specific EF and RA in the current study. Nevertheless, this interpretation is tentative, and given that the significant positive association between Conceptual Flexibility-specific EF and RA was unexpected, it requires further research. This is particularly important because the Conceptual Flexibility-specific component is composed entirely of variance from three parts of a single task (Card Sorting Test). Although the latent-variable approach in the current study reduces measurement error compared to the use of individual tasks (Bollen, 2014), it does not take into account potential shared method variance when the target component of EF is composed of multiple indicators from the same task. Thus, it will be important for future studies to use multiple task indicators from various tasks.

With regard to the associations between EF and PA, although it was tentatively hypothesized that both Conceptual Flexibility-specific and Monitoring-specific EF would be uniquely positively associated with PA, only Monitoring emerged as significant. Thus, the component of EF most relevant to planned, goal-directed aggression is the ability to monitor incoming information for relevance for the task at hand and then appropriately update online information with new, more relevant information. This is consistent with research indicating that antisocial behaviors requiring increased levels of planning and premeditation are associated with higher levels of EF, particularly monitoring- and conceptual-flexibility-related abilities (Barker et al., 2007). The lack of association between PA and Conceptual Flexibility-specific EF was thus somewhat unexpected. As noted previously, Conceptual Flexibility-specific EF represents the variance in performance on its respective tasks once the Common-EF variance has been extracted. It is possible that once this inhibition-related variance is removed, the variance unique to the ability to flexibly shift between mental sets and adjust action accordingly may not be as relevant to planned, goal-directed acts of aggression.

The distinct associations observed in the current study add to an existing literature that provides evidence of external constructs that distinguish between RA and PA (e.g., Ellis et al., 2009; Fite, Raine, Stouthamer-Loeber, Loeber, & Pardini, 2010; Hecht et al., 2016; Hecht & Latzman, 2015; McAuliffe et al., 2006; Miller & Lynam, 2006). The specific pattern of associations revealed within this study indicate that RA and PA are characterized by unique cognitive processes. That is, whereas RA is a stimulus-driven, disinhibited response, PA is driven by top-down control in the service of goal attainment.

In addition to clarifying the specific associations between components of EF and RA/PA, results from the current study have broader implications for our understanding of these constructs and the biological mechanisms that underlie them. Overall, results lend credence to the notion that RA and PA may arise from unique cognitive processes, which may be associated with unique brain regions. Indeed, recent neuroimaging research using the unity and diversity framework of EF indicates that the EF components also demonstrate common and unique neuroanatomical correlates (Collette et al., 2005; Sylvester et al., 2003). Indeed, within a nested, bifactor framework of EF, it has been suggested that unique neural networks underlie Common EF and Conceptual Flexibility-specific EF, which may help to explain their curious pattern of opposing associations with external constructs (Herd et al., 2014). Taken together with results from the
current study, it appears that although RA and PA are overlapping constructs, they may arise from distinct cognitive processes that implicate specific regions and/or networks within the brain. Thus, the current study lays the groundwork for future research to begin to consider the potentially unique pathways from brain-based mechanisms to specific subtypes of aggressive behavior.

**Strengths and limitations**

The current study exhibits a number of strengths that contribute to an overall improvement over existing literature in this area. First, the latent variable approach in the current study improves upon previous literature, as observed variables are impure measures of their constructs. This is an especially advantageous approach with regard to EF, as single tasks tapping EF abilities necessarily involve multiple lower levels processes (e.g., Miyake et al., 2000; Washburn et al., 2015). An additional strength of the current study was the use of a self-report measure of RA and PA, which was used to model latent RA/PA. This allowed access into the private motivations behind aggressive acts (Raine et al., 2006), and the latent variable approach allowed for a more pure measure of RA and PA than would be possible through observed variables (Bollen, 2014). Finally, the use of structural equation modeling approach in analyses allowed for the examination of the unique associations with RA and PA, independent of their overlapping variance.

Despite these strengths, the current study is not without its limitations. Given the cross-sectional, correlational nature of these data, it will be important for longitudinal studies to prospectively examine the prediction of subtypes of aggression from components of executive functioning. Further, the use of an undergraduate sample may limit the generalizability of these findings, and potentially contributes to a restriction of range problem in that participants drawn from a university community arguably demonstrate stronger than average cognitive abilities and low levels of aggression. Nonetheless, there is no reason to believe that these associations would not have emerged within a community sample, although the strength of associations may have been attenuated, resulting in a more conservative estimate of associations between EF and RA/PA. It is also important to note that without additional modalities of measurement assessing RA/PA in the current study, the accuracy of self-reported aggression must be interpreted cautiously.

In addition, it is possible that general intelligence may impact the associations between components of EF and RA/PA, as both EF (e.g., Engle, Tuholski, Laughlin, & Conway, 1999; Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001) and aggression (e.g., Moffitt, 1993) have been associated with intelligence. As such, it will be important for future research to consider the effect of intelligence on these associations. Nevertheless, given that EF and intelligence are separate constructs, and components of EF demonstrate a genetic influence that goes beyond the influence of intelligence alone (e.g., Friedman et al., 2008), specific associations between components of EF and subtypes of aggression would likely still remain above and beyond the influence of intelligence.

Moreover, although the latent variable approach employed in the current study represents a significant improvement upon previous research, both Conceptual Flexibility and Monitoring were composed of variance from performance on various parts of single tasks. While this is certainly an improvement over single-task indicators of EF, particularly given the latent variable approach, it is possible that the variance contributing to each EF component may include task-specific variance unrelated to the target EF component. This is especially a concern for Monitoring, which is modeled from only two scores, both of which are from the same task condition. Thus, it will be important for future research to increase both the number and variety of indicators for each component. Additionally, as noted previously, this is the first study to date to extend the nested, bifactor model of EF to more traditional neuropsychology-based EF tasks. Although this is a significant strength of this investigation, it will be important for future research to consider both cognitive as well as traditional neuropsychology-based EF tasks, as the use of both modalities would also contribute to alleviating the task impurity problem and reduce shared method variance.

Limitations notwithstanding, the current study makes an important contribution to the existing literature by providing the most in-depth and comprehensive assessment to date of the nuanced associations between executive functioning and subtypes of aggression. Results revealed that impulsive, provoked aggression is explained by decreased goal-directed inhibitory abilities and increased flexibility. In contrast, increased monitoring and updating abilities explain planned, goal-directed aggression. These findings underscore the importance of considering the multidimensional nature of EF, as well as the heterogeneity within aggression, rather than conceptualizing either as a single broad construct. Overall, it appears that aggression may not arise from purely deficits in cognitive functioning—rather, aspects of EF may decrease engagement in certain subtypes of aggression (e.g., goal-oriented inhibition), while others...
may contribute to tendencies toward specific subtypes of aggression (e.g., flexibility, monitoring).

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**References**


