Executive (Dys)Functioning and Impulsivity as Possible Vulnerability Factors for Aggression in Forensic Patients

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Abstract: This study investigated whether executive dysfunction and impulsivity are both predictors of reactive aggression and is the first to use behavioral assessment of aggression in response to provocation by means of a personalized boxing body opponent bag giving harassing feedback. Aggressive behavior, self-reported aggression, executive functioning (ie, working memory, flexibility, and divided attention), and impulsivity dimensions (ie, Sensation Seeking, Impulsive Decision Making, and [inadequate] Response Inhibition) were measured in 44 incarcerated psychiatric patients. Results show that both executive functioning (working memory) and impulsivity (Impulsive Decision Making) predicted self-reported reactive aggression, whereas Response Inhibition was the only predictor for reactive aggressive behavioral responses. The study suggests that Response Inhibition is a stronger predictor of reactive aggressive behavior than executive capacities of working memory, flexibility, and divided attention. Therefore, future research should investigate whether (inadequate) Response Inhibition could also be a valuable predictor for violent recidivism.

Key Words: Aggression, executive functioning, forensic, impulsivity, offenders

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"The Price of Victory, the Cost of Aggression" as Alexander Orlov (2005), a veteran of the Great Patriotic War, says in a reflection on the Battle for Berlin indicating the negative impact of violence and aggression. Aggression can be defined as "hostile, injurious, or destructive behavior" (Siever, 2008, p429) and can be distinguished in reactive and proactive aggression. Reactive aggression indicates spontaneous and emotion-driven responses to perceived threats (Cima and Raine, 2009) and is also referred to as hostile, impulsive, or angry aggression (Anderson and Bushman, 2002). Proactive aggression refers to forethought and planned, instrumental, goal-directed aggression (Berkowitz, 1993; Raine et al., 2006). Research shows that reactive aggression is associated with violent behavior (Mooney and Daffern, 2011; van Honk et al., 2010).

A convenient and common approach to assess aggression is self-report, like the Aggression Questionnaire (Buss and Perry, 1992), or pencil-and-paper version vignettes about provocative aggressive situations (O'Connor et al., 2001). While self-reports and vignettes are proven effective and valid in reflecting a person's characteristics and beliefs toward aggression (Edwards and Bond, 2012), and vignettes are valid methods to assess response to real life provoking situations (van Goozen et al., 1994), they are susceptible to social desirability, especially within forensic populations (Cima, 2003). Moreover, there are laboratory-based behavioral paradigms assessing aggression such as the Competitive Reaction Time Paradigm the Aggression Machine Paradigm (Buss, 1961), and the Performance Evaluation Paradigm (Berkowitz, 1962). All these behavioral paradigms include the punishment of another individual by giving electric shocks to the "opponent" as a measure of direct physical aggression. However, punishing someone by giving electric shocks might be more an indication of sadistic willingness than an indication of reactive aggressive behavioral response. We aim to contribute to a behavioral response measure that might be more ecologically valid than delivering shocks. Therefore, we developed a measurement of reactive behavioral aggression in the form of a personalized boxing body opponent bag (BOB) accompanied by boxing gloves with force sensors. To replicate a real life provocation, the BOB is giving harassing feedback triggered by punching (see Measures). In the current article, reactive aggressive behavioral response is the mean punching force after harassment.

Impulsivity has been defined in various ways (Bickel et al., 2012). The International Society for Research on Impulsivity defines impulsivity rather broadly as "behavior without adequate thought, the tendency to act with less forethought than do most individuals of equal ability and knowledge, or a predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions" (International Society for Research on Impulsivity; http://impulsivity.org/). We define and assess impulsivity in a 3-dimensional model, containing Sensation Seeking, Impulsive Decision Making (IDM), and (inadequate) Response Inhibition (Tonnaer et al., 2016, see Measures). Like impulsivity, executive functioning has been defined and measured in various ways (Elliot, 2013). For instance, Baker and Ireland (2007) used a word fluency test to tap into cognitive control of organization, whereas Hoaken et al. (2003) used a self-ordered pointing task to measure the ability to organize and monitor a series of responses. Executive functioning refers to cognitive control of planning and organization, attention, alertness, abstract reasoning, and regulation of behavior. In the current study, executive functioning is conceptualized focusing on 3 different components of executive functioning, namely, working memory, divided attention, and flexibility. The 3 different components have been selected because they all represent different aspects of executive functioning, thereby capturing the scope of this broad concept (Elliot, 2013; Suchy, 2009; Swami, 2013). Moreover, impairments in the 3 selected components are linked to elevated aggressive behavior (de Brito et al., 2013; Feichtinger, 2007; Wilson and Scarpa, 2011).

Empirical evidence shows that reactive aggressive behavior (RAB) correlates not only with impulsivity (Chan and Chui, 2012), but also with problems in executive functioning (Baker and Ireland, 2007). Although both impulsivity and executive (dys)functioning relate to RAB, the possible interrelation between both indicators of aggressive behavior remains unclear. Even more relevant to clinical practice and interventions, the possible interrelation between both indicators for aggressive behavior as a result of provocation remains unclear. For instance, it is not clear whether it is one of these factors or both that predispose to aggressive behavior. The aim of the current study is to investigate these relationships, in particular in a male offender sample, because the prevalence of maladaptive aggression tends to be specifically high in mental health treatment populations (Connor, 2002) like the study sample, as is the proneness toward aggression (Smith and Waterman, 2003).

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We hypothesized that executive dysfunction and impulsivity are both predictors of aggression and most particular for RAB (Bickel et al., 2012; Fischer and Smith, 2008). More specific, we expect an inverse relationship between executive functions and RAB. For instance, research shows working memory, as a component of executive functioning, capacity relates to externalizing problem behavior such as aggression and antisocial behavior in children (Ziermans et al., 2012). Consequently, the current study expects an inverse relationship between working memory and RAB. In addition, we expect an inverse relationship between all impulsivity dimensions and RAB as, for example, a lack of self-control—operationalized in the (inadequate) Response Inhibition dimension—is frequently stated as a central cause of aggressive behavior (Gottfredson and Hirschi, 1990; Swann and Hollander, 2002).

METHODS

Participants

In the current study, 44 incarcerated psychiatric patients undergoing mandatory treatment within Forensic Psychiatric Centre de Rooyse Wissel participated in the current study. The current study sample is a subsample of the database aimed to present a multidimensional model of impulsivity (Tonnaer et al., 2016). The ethical committee of Maastricht University and the research committee of FPC de Rooyse Wissel approved the research protocol. Participants were recruited by means of an information letter, by which they could give their consent to participate. All participants participated on a voluntary basis. They received written and oral instruction emphasizing that participation was not related to treatment or prospects for release and that participants were free to withdraw from the study at any time. Originally 46 offenders were recruited, but 2 withdraw because of a lack of interest or outplacement. All participants were male and ranged in age from 26 to 57 years (mean, 38.2 [SD, 8.3]). All participants were Dutch, 73% white non-Hispanic, 12% black non-Hispanic, 7% multiracial, 5% Asian/Pacific Islander, and 2% with Hispanic ethnicity. As to their educational level, 2% had attended only elementary school, 81% secondary school, and 17% had attended college. Regarding the type of offences, 33% of participants had been convicted for actual or attempted manslaughter or murder, 21% for sexual offences such as rape, 16% for sexual offences with minors, 14% for bodily harm, 7% for property crime with violence, and 9% were convicted for arson.

The 3 exclusion criteria were the presence of psychotic disorders, IQ score of less than 80, and insufficient comprehension of the Dutch language. Psychopathy Checklist–Revised (Hare, 1991, 2003) data were collected for all participants: total scores ranged from 10 to 36 (mean, 23.6 [SD, 6.9]). All Psychopathy Checklist–Revised interviews were scored for and discussed by 2 trained forensic professionals, resulting in a consensus score. In the current sample, 45.5% was psychopathic (n = 20, scored ≥26 indicating psychopathy) and 54.5% (n = 24) nonpsychopathic.

Regarding the type of psychopathology, 57% of participants met the diagnostic criteria for substance dependence (in full remission), 59% for antisocial personality disorder, 20% for intermittent explosive disorder, 32% for a single episode of a major depressive disorder (in full remission), 16% for borderline personality disorder, 11% for posttraumatic stress disorder, 11% for pathological gambling, and 11% for autism (all with a comorbidity rate of 89%).

All pathology was scored for scientific purpose (the current study) by semistructured interviews based on the fourth edition text revision of the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision* (*DSM;* American Psychiatric Association, 2013). All interviews were scored and discussed by professionals who were trained to administer the interview, resulting in a consensus score arrived by discussion of scoring differences.

Measures

Aggression

Reactive-proactive questionnaire

The Reactive Proactive Questionnaire (RPQ) was used as a self-report of aggression during lifetime (mean, 18.61 [SD, 9.38; range, 3–40] for RPQ-Total; mean, 11.84 [SD, 4.30; range, 3–21] for RPQ-R; mean, 6.77 [SD, 5.77; range, 3–21] for RPQ-P in the current sample) (Raine et al., 2006). The RPQ consists of 23 items that are rated on a 3-point scale (0 = never and 2 = always). The questionnaire includes 2 subscales of aggression: the proactive subscale, which measures proactive aggression in items such as "How often have you got others to gang up on someone else?" and the reactive subscale measuring reactive aggression in items such as "How often have you got angry or mad or hit others when teased?" Research has shown good internal reliabilities for total RPQ, and reactive and proactive subscale scores with all reliability coefficients exceeding 0.81 (Cima et al., 2013; Raine et al., 2006). The RPQ demonstrated good construct validity, convergent validity, criterion validity, and discriminant validity (Raine et al., 2006). Internal consistency in the current sample was excellent (Cronbach $\alpha = 0.92$ for RPQ total score, 0.83 for the proactive subscale, and 0.90 for the reactive subscale).

Body opponent bag with harassing feedback

Body opponent bag is used as behavioral assessment of reactive aggression in response to provocation (Tonnaer et al., 2016). The Plastisol Body Opponent Bag includes a height-adjustable full-size lifelike mannequin opponent bag including a water-filled base and weighs approximately 150 kg/330 lb. Four Flexiforce (A201 type) pressure sensors with a force range of 0 to 445 N are constructed on Lonsdale training gloves and connected with a laptop recording the force associated with punch impact in a frequency of 1 millisecond (Büscher et al., 2015; Lowe et al., 2004). Maastricht University has developed a BOB software program aimed to record and save the force in newtons (N) of each punch given by participants. In order to maximize the force sensitivity, the mean force of all 4 force sensors is registered (Falco et al., 2009; for a more detailed description and the validation of the current BOB assessment, see Tonnaer et al., 2016). Before the BOB testing procedure starts, participants are asked to weigh themselves, and the weight is registered in the software program. Participants are then instructed to "punch BOB," knowing that the beginning and end of the recording are indicated with a loud auditory start and stop signal. However, participants do not know that 15 seconds after the auditory start signal is given, harassing feedback is triggered by punching. Hereafter, a total of 6 different auditory feedback fragments are triggered in set order by a punch, each starting related to a punch and minimum 7 seconds after the last feedback. Boxing body opponent bag gives the following auditory feedback: (1) "You have to do better, this is nothing!" (2) "Can't you hit harder? We cannot measure anything!" (3) "Even my sister hits harder than you!" (4) "I don't feel anything yet!" (5) "The other participants hit much harder than you!" and (6) "Are you a man?" Recording stops 15 seconds after the last feedback. For the current study, the mean force after the last feedback was used to assess RAB, after this defined as the RAB response (mean, 17.89 [SD, 18.46; range, 6–120] N in the current sample).

Impulsivity

Impulsivity model

The impulsivity model consists of the factor scores of 3 distinctive impulsivity dimensions (Tonnaer et al., 2016; mean, 0.0 [SD, 1; range, −2.55 to 2.20] for SS; mean, 0.0 [SD, 1; range, −1.48 to 2.46] for IDM; mean, 0.0 [SD, 1; range, −2.34 to 2.28] for inadequate response inhibition in the current sample). The first dimension, incorporating the BIS-11 (Patton et al., 1995; mean, 16.64 [SD, 3.10; range,

10–24] for attention impulsiveness; mean, 21.32 [SD, 4.21; range, 14–30] for motor impulsivity; mean, 24.45 [SD, 4.59; range, 14–34] for non planning impulsivity in the current sample) and the I7 (Eysenck et al., 1985; mean, 7.75, range = 3–15 [SD, 3.04] in the current sample) Impulsiveness scale, named "Impulsive Decision Making," reflects acting without thinking about the consequences (Field, 1986) and is in the literature defined as the inability to delay gratification when tolerance results in a less risky outcome (Rachlin, 1974; Reynolds et al., 2006b) and the tendency to engage in spontaneous behavior, restlessness, and impatience (Field, 1986). The second dimension, incorporating the Balloon Analogue Risk Task (Lejuez et al., 2002; mean, 8.93 [SD, 3.76; range, 1–18] for explosions; mean, 917.23 [SD, 306.35; range, 267–1572] for pumps) and the I7 Venturesomeness scale, named "Sensation Seeking," reflects a risk appetite and is in the literature related to actual risk taking and aggressive, but not necessarily criminal, behavior (Eysenck et al., 1985; mean, 11.77 [SD, 2.92; range, 5–16] in the current sample). The third dimension, incorporating the GoStop Impulsivity Paradigm (GoStop; Dougherty et al., 2005; mean, 178.64 [SD, 66.84; range, −28 to 332] for GoStop Stop Latency [in milliseconds]; mean, 66.68 [SD, 12.20; range, 40–86] for GoStop Inhibition (%); mean, 403.76 [SD, 98.76; range, 172–626] for GoStop Latency [in milliseconds] in the current sample) and the Sensation Seeking Scale (Zuckerman et al., 1964; Disinhibition scale (mean, 4.12 [SD, 1.13; range, 2–6] in the current sample), named "(inadequate) Response Inhibition," reflects the failure to inhibit responding and disinhibited social behavior. Like the selected components of executive functions, all 3 selected impulsivity dimensions are related to aggressive behavior (Denny and Siemer, 2012; Lynam and Miller, 2004; Ramírez et al., 2009; Wilson, and Scarpa, 2011).

Executive Functioning

Test battery of attentional performance

The Test Battery of Attentional Performance (TAP; Ziermans et al., 2012) is a neuropsychological assessment of executive functioning. The TAP includes various subtests developed to assess a variety of visuospatial, nonspatial, and executive attention aspects such as alertness, divided attention, flexibility of focused attention, inhibitory processes, and working memory. In the current study, 3 subtests are used to assess executive functioning:

(1) Working Memory. In this subtest, a series of digits are presented on a screen. The participant is asked to react by pushing a button when the presented digit is identical to the second last digit shown. The TAP working memory test (mean, 597.65 [SD, 135.35; range, 313–954] in the current sample) has been able to show group differences between schizophrenic and control subjects in working memory (Huguelet et al., 2000).
(2) Divided Attention (dual-task condition, visual and auditory). This subtest presents a number of crosses simultaneously on the screen, combined with a series of high and low tones. The participants are asked to attend to 2 conditions, namely, when 4 crosses form a square on a 4 × 4 dot matrix (visual target) and when the same tone occurs twice (auditive target). In both instances, the participants have to press a button. The divided attention task of the TAP (mean, 733.43 [SD, 123.68; range, 530–1195] in the current sample) has shown acceptable reliability, expressed in coefficient α of 0.75 (Goldhammer et al., 2007).
(3) Flexibility (shapes alternating). This subtest presents 2 different stimuli (1 angular and 1 round) simultaneously and randomly at the right and left sides of the screen. The participants have 2 response buttons, one placed at the left and one at the right hand, and are asked to attend to the angular and the round target in turns, starting with the angular stimulus. The flexibility task of the TAP (mean, 908.08 [SD, 274.98; range, 492–1820] in the current sample) has shown good reliability, expressed in coefficient α of 0.97 (Goldhammer et al., 2007) and good validity and reliability in the neuropsychological assessment of executive functioning (Fimm et al., 2001; Rozas et al., 2008).

Data Reduction and Analysis

Normality of the raw data was checked, and outliers were corrected if necessary. Participants scoring higher or lower than 3 SDs from the mean were considered outliers (Tush et al., 2008). The following outliers were identified prior to the analysis, and the maximum value was set to a maximum of 3 SDs plus 1 scale point from the mean plus (or minus) 1 scale point: for divided attention, 1 outlier was corrected; for the TAP flexibility score, 2 outliers were corrected. Moreover, 1 individual did not complete the TAP in accordance to the instruction, resulting in missing values for this person. To investigate the relationship between executive functioning, impulsivity, and RAB, a correlational analysis was completed. Moreover, we did check for possible correlations between the level of education of all participants on the one hand and the measures of interest (aggression, impulsivity, and executive function) on the other hand, but no significant correlation was found. Therefore, we did not correct for the level of education in the following analysis. Furthermore, to check for possible moderation effects, all variables were centered, and 9 interaction variables were created (impulsivity dimensions * 3 executive functioning components). In order to examine whether executive dysfunction and impulsivity were predictive for RAB (both RAB response and self-report), 2 stepwise linear regression analyses ($p \leq 0.05$ to $p \geq 0.1$) were conducted. The executive functioning components (working memory, divided attention, and flexibility) and the impulsivity dimensions (Sensation Seeking, IDM, and [inadequate] Response Inhibition), along with their interaction variables, were stepwise entered simultaneously.

RESULTS

Correlations Between Aggression Measurements

The correlation between self-reported RAB (RPQ total and subscale scores) and RAB in response to provocation (RAB response) was not significant (Table 1), indicating possible distinct components of aggression. In addition, results corrected for the time interval duration and for mean force before feedback was given were similar to the reported results. Moreover, there was no relation between BOB results and weight.

Correlations Between Executive Functioning and Impulsivity

The correlations between the 3 executive functioning components (working memory, divided attention, and flexibility) and the 3 impulsivity dimensions (Sensation Seeking, IDM, and [inadequate] Response Inhibition) showed no significant relations, indicating distinct mechanisms (Table 1).

Correlations Between Impulsivity and Aggression

The correlations between the 3 impulsivity dimensions on the one hand (Sensation Seeking, IDM, and [inadequate] Response Inhibition) and both the self-reported RAB (RPQ total and subscale scores) and the RAB in response to provocation (RAB response) on the other hand showed a significant relation between IDM and the self-reported RAB and between (inadequate) Response Inhibition and the RAB response (Table 1).

Correlations Between Executive Functioning and Aggression

The correlation between the 3 executive functioning components (working memory, divided attention, and flexibility) and self-reported RAB showed a significant negative relationship between working

TABLE 1. Correlations of Aggression, Impulsivity Dimensions, and Executive Functions (N = 44)

Measure	BOB	RPQ	RPQ-R	RPQ-P	SS	IDM	RINH	WM	DA
RPQ (Total)	−0.23								
RPQ-R	−0.17	0.91**							
RPQ-P	−0.25	0.95**	0.73**						
Sensation Seeking (SS)	0.30	−0.11	−0.08	−0.12					
IDM	0.03	0.38*	0.40**	0.32*	0.13				
Response Inhibition (RINH)	0.34*	−0.17	−0.16	−0.16	0.04	0.00			
Working Memory (WM)	0.01	−0.21	−0.34*	−0.09	−0.08	−0.06	−0.07		
Divided Attention (DA)	0.04	−0.10	−0.12	−0.07	−0.28	−0.07	−0.05	0.31*	
Flexibility	−0.02	−0.13	−0.14	−0.10	−0.20	−0.11	0.01	0.13	0.60*

*$p < 0.05$.
**$p < 0.01$.

memory and the reactive aggression scale of the RPQ (Table 1). The correlations between the executive components and the RAB in response to provocation (RAB response) were not significant (Table 1).

Prediction of Aggression

Results of the stepwise linear regression ($p \leq 0.05$ [enter]; $p \geq 0.1$ [remove]) with the different executive functioning components, the impulsivity dimensions, and their interaction variables as predictors and self-reported RAB (RPQ-R) as target variable show that both executive functioning and impulsivity predict self-reported RAB, in particular IDM and working memory (Table 2). Moreover, results showed a significant F change indicating that the model with both predictors adds a significant value to 1 predictor (IDM) model (Table 2).

Results of the stepwise linear regression ($p \leq 0.05$ [enter]; $p \geq 0.1$ [remove]) with the different executive functioning components, the impulsivity dimensions, and their interaction variables as predictors and the RAB in response to provocation (RAB response) as target variable show that only (inadequate) Response Inhibition predicts the RAB response (Table 2).

DISCUSSION

The aim of this study was to investigate whether executive dysfunctions and impulsivity dimensions contribute to a greater risk of aggression, in particular for RAB in an offender sample. Our results can be summarized as follows. First, no significant relationship between executive functions and different impulsivity dimensions was found, indicating distinct components. Second, only working memory correlated negatively with self-reported RAB, but no relation between executive functioning and the RAB in response to provocation (RAB response) assessed with the BOB test was found. Third, IDM was related to self-reported RAB, whereas (inadequate) Response Inhibition was related to RAB response. Finally, stepwise regression analysis indicated that both executive functioning (working memory) and impulsivity (impulsive decision making) predict self-reported reactive aggression, whereas the impulsivity dimension (inadequate) Response Inhibition was the only predictor for the RAB response.

For this study, we hypothesized that executive dysfunction and impulsivity dimensions would be both predictors of RAB, because both are related to a greater risk of RAB (Blair, 2004; Mooney and Daffern, 2011; Raine et al., 2000). Our results indicated that executive dysfunction and impulsivity dimensions are distinct components. This is in contrast to earlier results that indicated 2 related construct (Bickel et al., 2012; Tedeschi et al., 2013). Because of the absence of generally accepted definitions for both concepts (Pennington and Ozonoff, 1996; Sergeant et al., 2003), studies focusing on executive functioning often also include impulsivity as a component of executive functioning (Mar et al., 2013; Sabbagh et al., 2006; Spinella, 2005). An explanation for the absence of a relationship between executive dysfunction and impulsivity dimensions is that the utilized methods tap into different processes representing differences in stable (trait, long term) versus instable (state, short term) concepts. Earlier research failed to show a significant relationship between state and trait impulsivity measurements (Wingrove and Bond, 1997). The current results point out that further research should not only distinguish both concepts, but also

TABLE 2. Stepwise Regression Analysis Results Predicting RAB (N = 44)

		B	SEB	*β*	*t*	*p*	*R*	R^2	R^2 Change
RAB response									
	Constant	17.91	2.97		6.03	0.00	0.35	0.12	0.12
	Inadequate Response Inhibition	6.17	2.86	0.35	2.15	0.04*			
RPQ-R									
Model 1	Constant	11.86	0.62		19.25	0.00	0.40	0.16	0.15**
	IDM	1.74	0.63	0.40	2.78	0.01**			
Model 2	Constant	11.86	0.59		20.25	0.00	0.51	0.26	0.10*
	IDM	1.66	0.60	0.38	2.78	0.01**			
	WM	−0.01	0.01	−0.32	−2.32	0.03*			

*$p < 0.05$.
**$p < 0.01$.

study them in various situations in order to learn more about these distinct mechanisms (Spielberger et al., 1988).

Furthermore, the current results showed a negative relationship between one executive functioning component (working memory) and self-reported RAB. But, in contrast to our expectations, no relationship between any executive functioning variable and RAB in response to provocation (RAB response) was found. This cross-domain finding between behavioral task performance of executive functioning (working memory) and self-reported aggression as opposed to the behavioral assessment of reactive aggression is informative in itself, given other research showing no relationship between self-report and behavioral assessment, for example, in aggression (Henry, 2006), as in other concepts such as impulsivity (Cyders and Coskunpinar, 2011; Reynolds et al., 2006a). Moreover, the behavioral operationalized executive functioning measures as well as the current utilized self-report of aggression might represent typical stable (trait) concepts (Bannon et al., 2006; Teten Tharp et al., 2011), whereas a behavioral measure such as the RAB response using BOB more likely represents a state-dependent concept (Anguera et al., 2013; Leshem and Glicksohn, 2007), which are not necessarily related (Wingrove and Bond, 1997).

More specifically, working memory as opposed to divide attention and flexibility seems especially trait like (Bailey et al., 2014), because working memory is a top-down cognitive control centre of attention (Ilkowska and Engle, 2010), with increasing working memory capacity resulting in better focus of attention (Colflesh and Conway, 2007) and cognitive flexibility (Blackwell et al., 2009).

Furthermore, we hypothesized a direct relationship between impulsivity and RAB, because research shows that reactive aggression is closely related to impulsivity (Bickel et al., 2012; Fischer and Smith, 2008). Indeed, IDM was related to self-reported RAB, which is in line with research in youth (Fontaine and Dodge, 2006), whereas (inadequate) Response Inhibition was related to RAB in response to provocation. This result is in line with aggression theories explaining aggression as a result of inhibition problems (Finkel et al., 2012) and low self-control (Gottfredson and Hirschi, 1990).

A combination of both executive dysfunction (working memory) and impulsivity (Decision Making) predicted RAB. However, this was only the case for self-reported RAB and not for the actual RAB in response to provocation. Apart from the trait versus state explanation referring to different concepts (Anguera et al., 2013; Leshem and Glicksohn, 2007), another explanation could be that our experimental task for assessing the RAB in response to provocation (RAB response) might fail in validity. Indeed, the validation of BOB within a male forensic population has yet to be presented in a manuscript that we are preparing for publication, but we aim to be as transparent as possible on the implementation of the RAP response with respect to its replicability. However, research indicates that hitting a punching bag increases anger (Bushman, 2002). Furthermore, several aggression theories, such as the self-control theory of crime, explain aggression as a result of low self-control (Gottfredson and Hirschi, 1990). The exciting transfer theory (Zillmann, 1983) indicates that physical activity during a prevocational situation might increase anger. Punching a fictive person, who gives harassing feedback, therefore seems an adequate method to elicit aggressive behavior in an ecologically valid way.

Ultimately, it would be interesting to investigate whether (inadequate) Response Inhibition is a predictive factor not only for RAB, but also for violent recidivism because RAB is often associated with violent behavior (van Honk et al., 2010).

The results of the present study must be seen in light of the following limitations. First, the sample size was small; thus, results should be interpreted with caution. For instance, with higher sample size, additional predictors might emerge. One avenue for further research could therefore be to test whether the type of pathology and psychopathy moderates the relationships between predictors and dependent variables. Second, no control groups and no female participants were included. We recommend that further research include nonpatient as well as nonforensic clinical control groups including women. Third, the generalizability of our study might be limited because of the context of a high security hospital. Perhaps, a less restricted setting is more suitable to provoke reactive aggression.

Fourth, the generalizability of the results on executive functioning and impulsivity is limited only to the assessed aspects in the current study (working memory, divided attention, flexibility and Sensation Seeking, IDM and [inadequate] Response Inhibition, respectively); research using other aspects of executive functioning, for example, might result in different findings. Moreover, given the results of de Brito et al. (2013), indicating possible difference between "cool" and "hot" executive functioning processes, future research should incorporate both processing types as we tapped only the "cool" type in the current study.

In conclusion, the literature shows that both impulsivity and executive dysfunction are related to aggression and violent crimes (Baker and Ireland, 2007; Hoaken et al., 2003; Lane and Cherek, 2000; Scarpa and Raine, 2000). The current study not only showed that both executive dysfunction and impulsivity seem distinct components—in a forensic population—but also even more important, it showed that the impulsivity component of (inadequate) Response Inhibition was the essential predictor for RAB in response to provocation. Consequently, future research should investigate if (inadequate) Response Inhibition could also be a valuable predictor for violent recidivism. Furthermore, risk management and aggression management programs for violent individuals with impulsivity problems should target specifically on inhibition problems.

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DISCLOSURE

The authors declare no conflict of interest.

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