Executive Functions as the Mechanisms underlying Proactive and Reactive Aggression in Child and Adolescent Boys.

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Preface

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Abstract

The investigation of aggressive behaviors in specific types – reactive and proactive – on the basis of knowledge about executive dysfunctioning is important for determining both the etiology and the treatment strategies for aggression. The present study aimed to identify executive functions as the mechanisms underlying reactive and proactive aggression. Twenty-seven boys from 7 to 12 years old (*M* = 9.78, *SD* = 1.37) participated in this study. We created a sample including boys with different types of aggression and a wide range of aggression scores. Several (computerized) neurocognitive tasks were used for the measurement of the executive functions: inhibition, attention, frustration tolerance, cognitive flexibility and planning. A teacher questionnaire was administered for the reactive and proactive aggression scores of the boys. We found that the executive dysfunctions were associated with higher levels of aggression. Inhibition problems were associated with both types of aggression, but we also delineated unique factors in the prediction of reactive or proactive aggression. These results are not only important for theoretical frameworks about the etiology of aggression, but we can also underpin the importance of stimulating the development of specific executive functions for the prevention and treatment of different types of aggression.

Keywords: Proactive and reactive aggression, executive functions, inhibition, children and adolescents.

Introduction

Aggression is a topic extensively investigated across multiple disciplines and fields of study. Aggression among humans has been grouped into different types and by means of different operationalizations, in order to investigate the divergence of externalizing behaviors. Among children, aggression and antisocial behavior are two of the most common childhood mental health problems requiring substantial intervention (Burke, Loeber, & Birmaher, 2002). Since there is a great need for prevention and intervention programs to suppress aggressive and violent behaviors in young children and adolescents, the underlying mechanisms and causal pathways leading to aggression form a topic of major interest (e.g., Van Goozen, 2005). A better understanding of the concept of ‘aggression’ and the mechanisms leading to aggressive and violent behaviors will make it possible to delineate core aspects for treatment. Therefore, our study focused on neuropsychological factors as predictors in the development of two types of aggressive behavior: proactive and reactive aggression.

Aggression is a heterogeneous phenomenon occurring in many forms, situations and groups of individuals. To better understand the nature and underlying constructs of aggression, many researchers made distinctions between various types of aggression (e.g., Dodge, 1991; Kempes, Matthys, De Vries, & Van Engeland, 2005; Vitaro, Barker, Boivin, Brendgen, & Tremblay, 2006). One common distinction made is the division of aggressive behavior into reactive or proactive aggression. One of the first definitions for these types of aggression was offered by Dodge and Coie (1987), who defined reactive aggression as a response to a perceived threat or provocation, and proactive aggression as behavior in anticipation of a reward. Multiple labels have appeared in the literature, referring to concepts similar to reactive or proactive aggression. Reactive aggression is also referred to as impulsive, defensive, hot-blooded, and affective aggression. It results from provocation and involves angry outbursts. This type of aggression includes affective and impulsive reactions to events, but not intentional acts. Proactive aggression is also termed non-impulsive, premeditated, goal-oriented, calculative, cold-blooded, predatory, and controlled aggression. The meaning and function of proactive aggression is goal-oriented: either toward the possession of objects or toward dominating people. This type of aggression is often displayed in a more covert manner, whereas reactive aggression entails more overt aggressive behavior (Dodge, 1991; Kempes, Matthys, De Vries, & Van Engeland, 2005;

Ramirez & Andreu, 2006; Vitiello & Stoff, 1997). Most researchers using a variety of terms for different types of aggression try to stress the importance of a differentiation in order to better understand the origins of aggression, and to create treatment strategies for these dysfunctional behaviors (Mathias et al., 2007; Merk, Orobio de Castro, Koops, & Matthys, 2005). However, although the concepts of 'reactive' and 'proactive' are considered distinct types of aggression including behavioral, social, and psychological differences, they co-occur in a large population of aggressive children (Walters, 2008; Polman, Orobio de Castro, Koops, van Boxtel, & Merk, 2007; Vitaro, Brendgen, & Tremblay, 2002). These findings suggest that there could be underlying mechanisms that lead to a combination of types of aggression in certain individuals. Because it is still quite unclear what factors may lead to the development of reactive, proactive or both types of aggression, studies investigating these mechanisms are of great importance.

From the neuropsychological perspective it is suggested that a mechanism underlying aggression in general is executive cognitive dysfunctioning (Goldstein et al., 2007; Lewis et al., 2008). Executive functions are higher-order cognitive abilities that develop from late infancy through adulthood and facilitate successful goal attainment via strategic planning, self-regulation, mental representation, and effective problem solving (Séguin & Zelazo, 2005; Weyandt, 2005). The core executive functions are working memory and inhibitory control, the latter including selective attention processes and self-control (Diamond, 2006). These are the fundamental building blocks with which the more complex executive functions are built, resulting in an extensive list of functions: abstract reasoning, critical thinking, attention control, cognitive flexibility, hypothesis generation, creative problem-solving, temporal response sequencing, and the ability to organize and adaptively use information contained in working memory (Giancola, Mezzich, & Tarter, 1998; Hawkins & Trobst, 2000). The executive functions have been linked to multiple psychological processes that are believed to provide a basis for effective problem solving, self-regulation and behavioral control (Morgan & Lilienfeld, 2000). In individuals with aggression problems these psychological processes are thought to be disrupted and malfunctioning. Several researchers found consistent relations between executive functions and aggressive behavior throughout childhood - generally investigated in clinically aggressive individuals (e.g., Goldstein et al., 2007; Lewis et al., 2008; Séguin & Zelazo, 2005). Especially when motivational processes were involved – i.e., the emotion regulation processes involved in stressful events, such as the drive to win a game and to earn a reward – children with disruptive behavior disorders showed dysfunctions in executive functioning processes (Blair, Colledge, & Mitchell, 2001; Van Goozen et al., 2004). These deficits in executive functioning can be considered problem solving and regulation failures (Ellis, Weiss, & Lochman, 2009). Additionally it was found that deficits in executive functions – especially inhibitory control – led to the development of disruptive behavior disorders: Oppositional Defiant Disorder (ODD) and Conduct Disorder (CD) (Schoemaker et al., 2012). The idea that the executive dysfunctions lead to abnormal behavior in clinically aggressive children has made researchers interested in the particular cognitive processes and functions that lead to particular behavioral outcomes. Because it was found that aggressive behaviors have different functions and express themselves in different forms, this means that potentially there are specific executive functions that lead to the development of reactive and/or proactive aggressive behaviors (e.g., Matthys, et al., 2005). In order to understand the mechanisms underlying reactive and proactive aggression several executive functions should be investigated. Although in the literature there is much evidence for the relations between several executive dysfunctions and aggression in clinically aggressive individuals, to our knowledge relatively little research has been done into the question whether relations regarding the origins of aggression in clinical samples can also be generalized to the normative population. We wanted to find out whether these relations are comparable for all individuals, in order to draw conclusions about general human mechanisms for different types of aggression. Therefore, in this study we hypothesized that several executive functions are significant predictors of the levels of reactive and proactive aggression, in a sample including boys showing different types and levels of aggression.

These kinds of studies have great relevance, since the development of aggression in childhood comes with several disadvantages and problems both then and in later life. Aggressive children experience problems in social relations, friendships, finding a job, and are more likely to develop delinquent behaviors (e.g., Farrington, 1991; Sebanc, 2003). Additionally, proactive aggression is often found to be related to psychopathic personality traits, which is another indicator for the relevance of early prevention and intervention in these children (Cima & Raine, 2009; Andrade, 2008). Since Frick and Loney (1999) found that antisocial and aggressive disorders are very expensive to society in comparison with typically developing boys, these studies have also been of great importance for society. Understanding the origins of aggressive behaviors can provide insight into what should be core aspects of prevention and intervention programs (e.g., Mathias et al., 2007; Ramirez & Andreu, 2006). With this kind of knowledge interventions could be started at an earlier point in development, which could prevent young aggressive boys from developing antisocial behavior, disruptive behavior disorders (ODD and CD), antisocial personality disorder (ASPD), and delinquency and violence (Brendgen et al., 2001; Carlotta et al., 2011; Fite, et al., 2010; Scarpa et al., 2010; Vazsonyi et al., 2006; Vitaro et al., 1998). The potential differences between predictors for the development of reactive and/or proactive types of aggression are also of great importance. Vitaro and colleagues (1998 & 2002) showed that proactive aggressiveness during pre-adolescence predicted delinquency, ODD, and CD problems during mid-adolescence, whereas reactive aggressiveness did not. Pulkinnen (1996) showed that many proactive aggressive male adolescents were likely to exhibit criminal behavior later in life, but reactive aggressive adolescents were not. Thus, the classification of aggressive behaviors into specific types – reactive and proactive – on the basis of knowledge about executive dysfunctioning is important for determining both the etiology (Barratt et al., 2000) and the treatment strategies for aggression (Crick & Dodge, 1996; Mathias et al., 2007).

Method

Participants

As higher rates of antisocial behavior generally are exhibited among boys (Zahn-Waxler e.a., 2008), the present study was restricted to males. Two data sets including the same variables were combined for the present study: the Amsterdam ‘Top 600’ study, which recruited participants from Amsterdam and surroundings, and the Leiden ‘PMTO’ study, which recruited participants from The Hague and Schiedam and surroundings. The combined sample consisted of 27 participants from merely the urban environment in the (north) west of the Netherlands. With the perspective on creating a sample that would include different types of aggression and a wide range of aggression scores, boys were recruited from both (public) primary schools and the youth mental health institution Forta Group in Schiedam. The age of the boys ranged from 7 to 12 years old (M = 9.78, SD = 1.37). The general socioeconomic status of the boys was based on the years of education of both parents: 28.6% finished secondary school or MBO, 47.6% was lower. The ethnicities of the participants were mainly Dutch (38.1%) and Moroccan (14.3%). Since the participants were of minor age, the boys’ parents signed a written informed consent form in which the study was described in detail. The present study was approved by the local ethics committee according to the declaration of Helsinki (1964).

Procedure

For the present study, participants were administered several neurocognitive tasks to assess executive functions in a standardized setting. These neurocognitive tasks and an aggressive behavior-questionnaire were administered in both the Amsterdam study and the Leiden study, however in slightly different ways. In Leiden, the neurocognitive tasks were administered on two time points with an interval of one week on average. To begin with, a standardized laboratory session was completed at the University of Leiden. Second, a structured cognition session was accomplished on either the Forta Group or in a classroom at the (public) primary schools. In the laboratory session a competition with a (figurative) opponent was introduced to the participant. Hence, a stress protocol was included and boys were highly motivated to win the game. Under these circumstances the frustration tolerance of the participants was examined, and all other neurocognitive tasks were administered in the cognition session one week later. For the participants in Amsterdam all neurocognitive tasks were administered at one time point at the primary schools of the boys. The teacher questionnaire about the aggressive behaviors of the boys was completed by teachers at the primary schools or by telephone.

For participation in this study, the boys received a present after each testing session, and parents were offered full reimbursement of travel expenses and a gift card.

Measurements

Reactive and proactive aggression. The Instrument for Reactive and Proactive Aggression (IRPA) was designed by Polman and Orobio de Castro (2008) to assess the form of aggression separate from the function. Teachers were asked to rate the frequency of seven forms of aggressive behavior – e.g., hitting, kicking, and gossiping – in the past month on a five-point scale. Moreover, teachers rated six functions of each of these forms of behavior, such as: the participant exhibited this behavior because he was angry, or because he enjoyed it. The different functions of behavior were divided into two dimensions: reactive and proactive aggression, ranging from low to high scores of aggression. Total scores were calculated for each dimension from the teacher report version of the IRPA. The choice for using only the teacher report was supported by findings that teacher reports of child behaviors are generally more valid than parent reports (Hart, et al., 1994; Shaffer, Lucas, & Richter, 1999). Children usually exhibit their aggressive behaviors in the presence of peers, which is more often realized in the school situation among teachers. Polman and colleagues (2009) found good validity of the IRPA in a sample of 427 children in the age of 10 to 13 years old. Excellent discriminant validity was found, indicated by the independency of the two constructs: reactive and proactive aggression (r = .03). Good construct validity was found, since reactive and proactive aggression uniquely correlated with most a priori hypothesized theoretically relevant variables. The convergent validity was satisfactory: The scores from the widely used TRI (Dodge & Coie, 1987) related moderately to highly with the scores from the IRPA.

Sustained attention. The subtest Sustained Attention Dots (SAD) of the Amsterdam Neuropsychological Tasks (ANT) was used to measure the sustained attention processing of the participants. This computerized task required the participant to sustain attention to a minimally interesting task for an average duration of fifteen minutes, and an average number of 600 trials. The participant was asked to press the right mouse button if four dots were presented on the computer screen. If the participant viewed three or five dots, he was asked to press the left button on the mouse (for left handed participants, the mouse buttons were reversed). Two measurements were used as indicators of the ability to sustain attention: the fluctuation in speed of reaction to the presented stimuli across the entire task, and a percentage score of missed stimuli, since these measures were considered to reflect inattention. For the variable ‘percentage score of missings’ 24 participants were included in the analyses. The validity and reliability of the ANT tasks were examined in a sample of 2250 children in the age of 10 to 12 years old (Brunnekreef et. al., 2003). The SAD had an effect size of: hp2 = .35 (time-on-task, percentage errors), moreover it was concluded that the effect sizes for (almost) all ANT tasks were satisfactory and in expected direction. Test-retest correlations of speed of processing and reaction were calculated for the SAD ($.90 < r < .94$), and it was concluded that the test-retest reliability for the entire ANT was moderate to high (De Sonneville, 2005; Günther, et al., 2005).

Inhibition. To measure inhibition of actions and behavior we used the subtest Shifting Attentional Set Visual Part 2 (SSV) of the ANT. This task was administered on the computer: the boys viewed a red block on the screen moving in left or right direction in random order. The boys were asked to press the mouse button incongruent with the direction of the red block; thus pressing the left button if the block moved right and vice versa. The required action in this task involved inhibition of behavior. This second part of the SSV included 40 trials and had an average duration of four minutes per participant. The total amount of inhibition errors – pressing the button congruent with the direction of the red block – and the average reaction time required for the actions were used as indicators of inhibition skills.

Cognitive flexibility. The third part of the SSV was administered to assess cognitive flexibility: the ability to efficiently shift attention and focus between different stimuli. In this part green or red blocks were alternately and randomly presented on the computer screen. The presented block moved in left or right direction in random order. The child was asked to press the mouse button congruent with the direction of the green block, but incongruent with the direction of the red block. Hence, the child needed to shift attention between different strategies for different stimuli. This third part of the SSV included 80 trials and had an average duration of seven minutes per participant. The total amount of errors in this third part of the SSV and the average reaction time required for the actions were used as indicators of cognitive flexibility skills. For the average reaction time indicator 26 participants were included in the analyses.

Frustration tolerance. To assess the frustration tolerance of the participants the Delay Frustration (DF) of the ANT was administered. In the Leiden study it was assumed that stress would increase the frustration in a task; therefore differences in participants' tolerance during frustration would be best tested in a stressful environment. The computerized DF task included an average number of 56 trials and had an average duration of nine minutes. The participant was asked to compare one figure – e.g., square, circle, or star – in a certain color – e.g., red, blue, or green – with four other figures of different shape and color. The boys were asked to click on one of the figures from which the shape or color was comparable to the presented figure. The computer provided the participant with a sound when the answer was correct, and continued with the next trial. However, in some trials the computer was programmed to wait a certain amount of time before continuing to the next trial, in order to increase the frustration in the participant. The participant thought he answered correctly, but the computer did not respond. The total number of clicks on the mouse button following this unexpected ‘computer error’ was used as an indicator of frustration (we used the inverted operationalization: frustration tolerance). For this variable 23 participants were included in the analyses.

Planning ability. The ability to efficiently formulate and implement a plan was measured with the Zoo Map task (ZM) from the Behavioral Assessment of the Dysexecutive Syndrome (BADS) test battery of Wilson and colleagues (1996). In this task participants were asked to plan a route through a zoo, in order to visit certain animals and places. The participants were provided with a set of rules that prohibited them from using certain paths twice, such that the participants were obliged to plan a route beforehand. This task was administered twice, with the second task being structured. The participants were asked to plan a second route; however in this task the order of visiting the animals was predetermined. A total score was calculated for each task, summing up all correctly visited places and subtracting the number of errors made by visiting other animals, using a path twice, or deviating from the path. The total scores were transformed into norm scores, used as indicators for planning ability with or without structure. For these variables 23 participants were included in the analyses. Chamberlain (2003) found high inter-rater reliability for the BADS (between .88 - 1.00). Test-retest reliability was assessed in a small sample and a substantial practice effect was found (correlations between BADS scores ranging from -.08 until .71). The poorest correlations were attributed to the outliers in the small sample. Face validity was found moderate, moreover a high construct validity, and a sufficient concurrent validity were found.

Data analysis

To estimate first-order relations among the factors in the prediction of types of aggression, correlations between all independent variables were examined. These could provide insight into the possibility of multicollinearity. Spearman pairwise correlations were used, for these are generally used in studies with small sample sizes, they are the least sensitive to outliers, and they are suitable for non-parametric testing (Lund & Lund, 2012). Furthermore, a correlation between the dependent variables ‘proactive’ and ‘reactive aggression’ was included, to investigate this bivariate association. We wanted to examine to what extent the two types of aggression related to each other in order to verify the differentiation between proactive and reactive aggression. We examined graphs for the distribution of aggression scores and the relation between the two different aggression types, and plots for the relations between the executive functions and the dependent variables. Multiple regression analyses, using the backward procedure, were performed on 19 participants of whom complete data were available (Myers, 1986), to predict reactive and proactive aggression from the several executive functions in a participant group including low to high scores of aggression. An alpha level of .10 (two-tailed) was used to indicate statistical significance.

Results

Reactive and proactive aggression

The histograms with normal curves depict the distributions of aggression scores in our sample for both reactive and proactive aggression (Figures 1 and 2). It was found that the distribution of reactive aggression scores was slightly right-skewed (γ = 1.02, SE = .45), the distribution of proactive aggression scores was more evenly distributed on both sides of the mean (γ = .47, SE = .45). Table 1 presents the descriptive statistics of the two aggression types. It was found that reactive aggression had a higher mean and a wider range of aggression scores compared

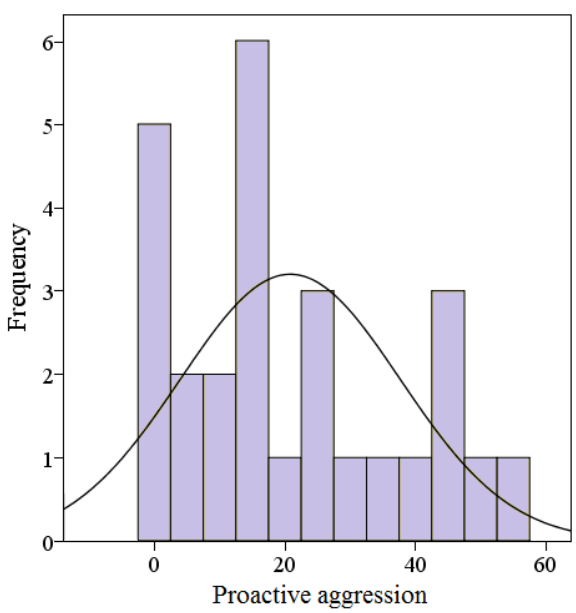

Figure 1. Distribution of proactive aggression scores.

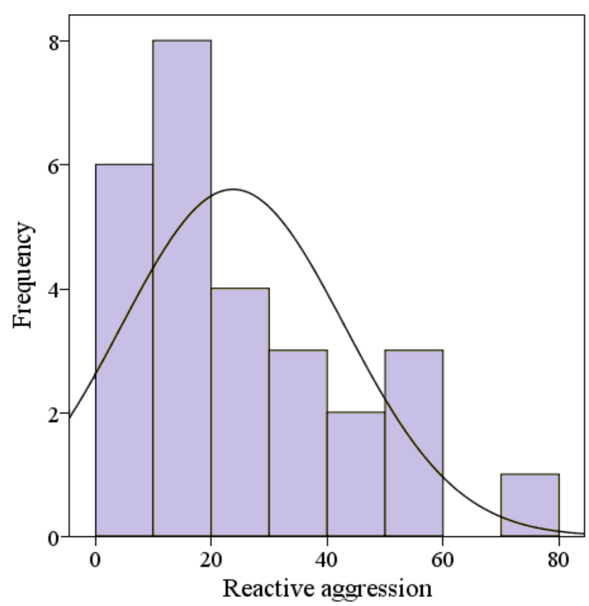

Figure 2. Distribution of reactive aggression scores.

with proactive aggression. The scatter plot of the two aggression types indicated a distribution with a moderate estimated fit toward a linear relation (Figure 3). A significant correlation was found between the two dependent variables proactive and reactive aggression ($r(25) = .63$, $p < .01$); high scores on reactive aggression related strongly to high scores on proactive aggression.

Correlations among predictors

A high number of inhibition errors was related to a high number of errors in the cognitive flexibility task ($r(25) = .66$, $p < .01$). Moreover, inhibition was moderately correlated with sustained attention, measured as fluctuation in speed of reaction during the task ($r(25) = .48$, $p < .05$). When the second indicator of inhibition was examined, it was found that low reaction times were related to low reaction times in the cognitive flexibility task ($r(24) = .65$, $p < .01$) and to a low fluctuation in speed of reaction in the sustained attention task ($r(25) = .43$, $p < .05$). The measure of frustration in the participants negatively correlated with cognitive flexibility in reaction time ($r(20) = -.49$, $p < .05$). Table 1 presents a detailed overview of the correlations and the descriptive statistics of the predictors.

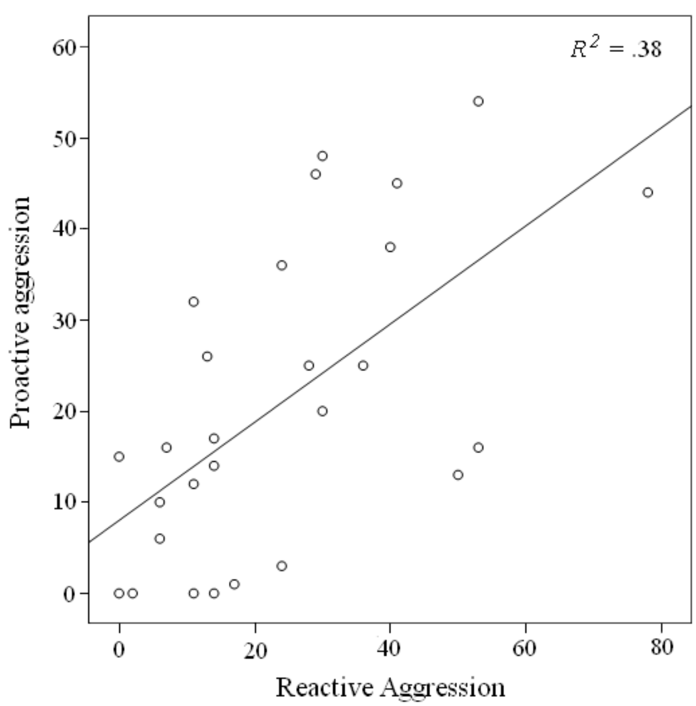

Figure 3. The relation between reactive and proactive aggression.

Table 1.

Descriptive statistics, correlations among the predictors and among the two types of aggression.

	1	2	3	4	5	6	7	8	9	10	11	*M*	*SD*	Min	Max
1 Proactive aggression	-											20.81	16.84	.00	54.00
2 Reactive aggression	.63**	-										23.78	19.24	.00	78.00
3 Inhibition errors	.37^	.26	-									6.85	5.33	.00	16.00
4 Cognitive flexibility errors	.21	.16	.66**	-								9.74	7.11	1.00	24.00
5 Inhibition reaction time	.21	-.08	.32	.22	-							814.30	325.18	406.00	1871.00
6 Cognitive flexibility reaction time	.00	-.31	-.19	-.17	.65**	-						1015.54	402.89	298.00	2192.00
7 Sustained attention fluctuation	.07	-.16	.48*	.27	.43*	.14	-					3.10	1.50	1.12	6.19
8 Sustained attention missings	-.16	-.02	.11	.02	.05	-.11	.19	-				16.97	11.30	2.00	50.00
9 Frustration tolerance	.17	.22	.22	.02	-.29	-.49*	.02	-.15	-			260.35	194.12	27.00	661.00
10 Planning ability unstructured	.09	.21	-.17	-.08	.34	.24	.10	.08	-.13	-		8.39	3.19	1.00	14.00
11 Planning ability structured	.47*	.44*	-.11	-.07	.29	.23	.04	-.03	-.21	.43*	-	5.70	4.20	.00	12.00

**. Correlation is significant at the .01 level (2-tailed). *. Correlation is significant at the .05 level (2-tailed). ^. Correlation is significant at the .10 level (2-tailed).

The prediction of proactive aggression

Multiple regression analyses showed that the regression model including the variables ‘inhibition’ (measured in errors), ‘frustration tolerance’, and ‘planning ability structured’, explained the highest proportion of variance in proactive aggression ($R^2 = .52$, $F(3, 18) = 5.31$, $p < .05$). Including other variables of executive functions in the regression model added minor proportions of explained variance to the model; however the standardized slopes of these variables were not significant, nor tended toward significance. The best prediction of proactive aggression was found by using the model as presented in Table 2. Part and partial correlations indicated a moderate to high uniquely explained variance in proactive aggression by both planning ability ($r^{\text{partial}} = .61$; $r^{\text{part}} = .54$) and inhibition ($r^{\text{partial}} = .55$; $r^{\text{part}} = .46$). Frustration tolerance uniquely explained a low to moderate proportion of variance in proactive aggression (Table 2). The standardized slope of ‘frustration tolerance’ was not significant in this regression model ($\beta = .30$, $p > .10$). Excluding this variable from the model created a smaller proportion of explained variance in proactive aggression, which tended toward a significance change (R^2 change = -.09, $F(1, 15) = 2.64$, $p = .12$,); it was therefore decided to include this variable in the predictive model of proactive aggression. The distributions and relations between the significant predictors and proactive aggression are presented in Figures 4 and 5. Positive linear relations are depicted for both inhibition and planning ability.

The prediction of reactive aggression

The highest proportion of variance in reactive aggression was explained by the model including the variables ‘inhibition’ (measured in errors), ‘cognitive flexibility’ (measured in errors), ‘sustained attention’ (measured in fluctuation) and ‘planning ability structured’ ($R^2 = .51$, $F(4, 18) = 3.63$, $p < .05$). Including other variables of executive functions added minor proportions of explained variance to the model; however the standardized slopes of these

Table 2.

Multiple regression analysis for the prediction of proactive aggression including mean centered predictors.

	F	R^2	*B*	SE	β	*t*	*p*	*Partial-r*	*Part-r*
(Constant)	5.31*	.52					.01		
Planning ability structured			2.27	.75	.55	3.01	.00	.61	.54
Inhibition errors			1.59	.62	.47	2.58	.02	.55	.46
Frustration tolerance			.03	.02	.30	1.63	.13	.39	.29

*. Significant at the .05 level (2-tailed).

Table 3.

Multiple regression analysis for the prediction of reactive aggression including mean centered predictors.

	F	R^2	*B*	SE	β	*t*	*p*	*Partial-r*	*Part-r*
(Constant)	3.63*	.51					.03		
Inhibition errors			3.28	1.02	.86	3.22	.00	.65	.60
Sustained attention fluctuation			-6.99	2.67	-.53	-2.62	.02	-.57	-.49
Planning ability structured			1.36	.88	.30	1.54	.15	.38	.29
Cognitive flexibility errors			-1.12	.82	-.35	-1.37	.19	-.34	-.26

*. Significant at the .05 level (2-tailed).

variables were not significant, nor tended toward significance. The best prediction of reactive aggression was found by including the four executive functions in the model as presented in Table 3. Part and partial correlations indicated a moderate to high uniquely explained variance in reactive aggression by both inhibition ($r^{partial}$ = .65; r^{part} = .60) and sustained attention ($r^{partial}$ = -.57; r^{part} = -.49). Planning ability and cognitive flexibility explained a low to moderate proportion of variance in reactive aggression (Table 3). The standardized slopes of the latter two variables were not significant (β = .30, p > .10; and β = -.35, p > .10), however it was decided not to exclude these variables from the model, since this created a smaller proportion of explained variance in reactive aggression which tended toward significance (R^2 change = -.10, $F(1, 15) = 2.51$, p = .13). The distribution of scores and the relations between the significant predictors and reactive aggression are presented in Figure 6 and 7. A negative relation is depicted between sustained attention measured in fluctuation and reactive aggression. No significant outliers were detected in all of the distributions from variables in both regression models. Inhibition (measured in errors) was the single executive function that was significantly related to both reactive and proactive aggression in the multiple regressions. Positive relations with both aggression types are depicted for this predictor (Figures 4 and 6).

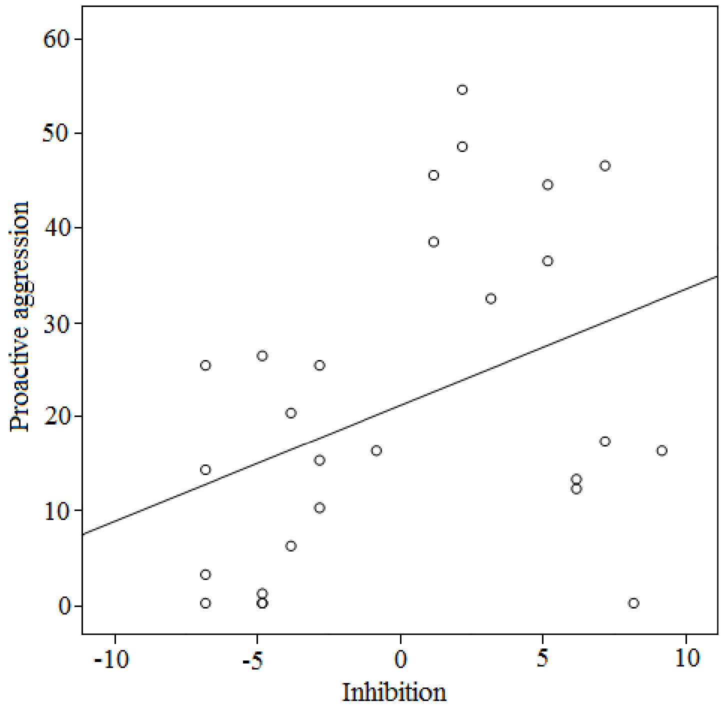

Figure 4. The relation between inhibition problems and proactive aggression

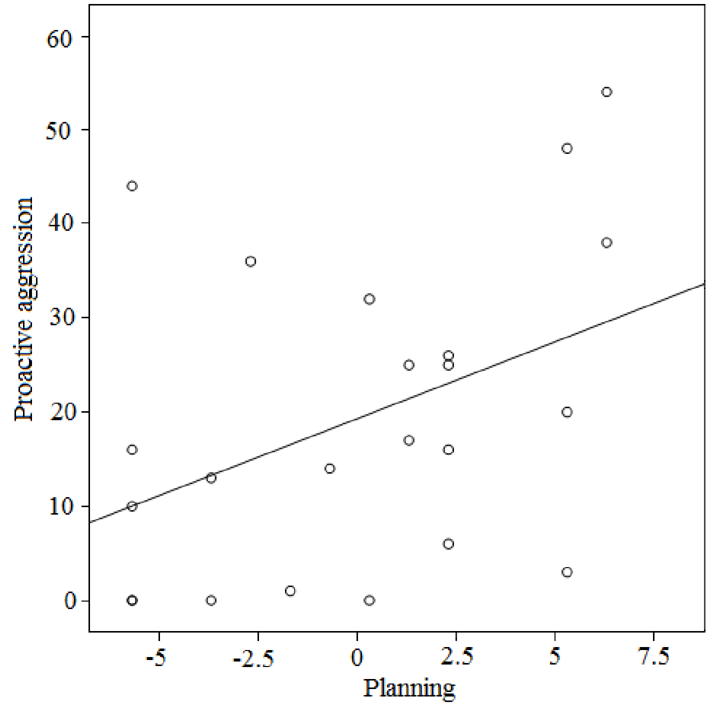

Figure 5. The relation between planning ability and proactive aggression

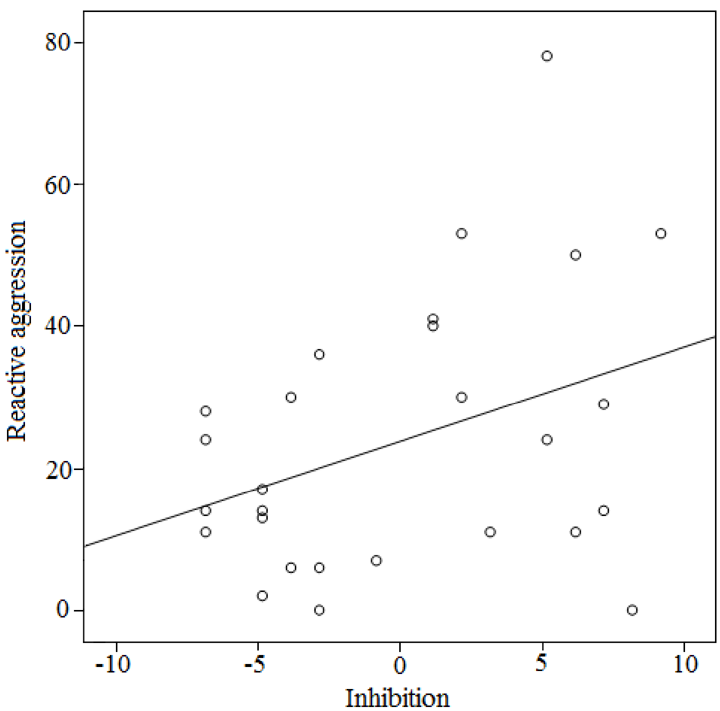

Figure 6. The relation between inhibition problems and reactive aggression

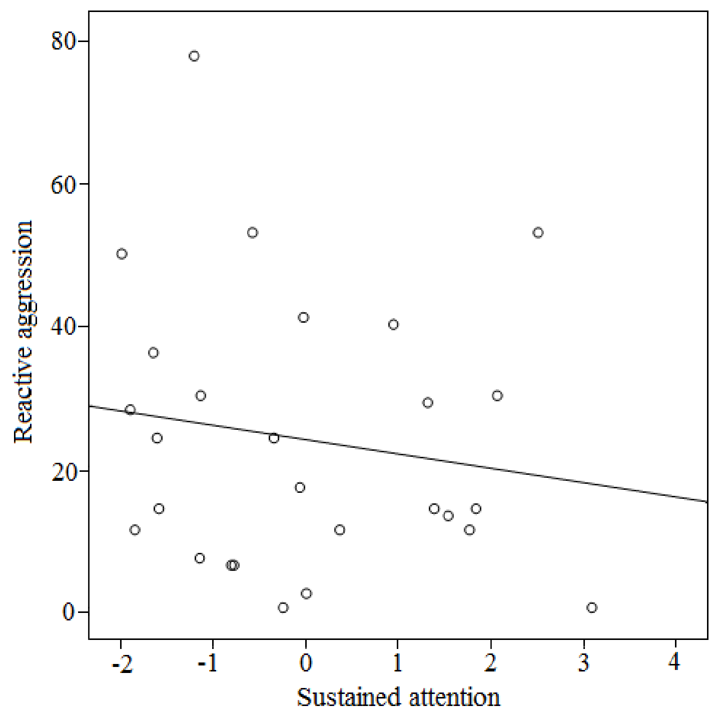

Figure 7. The relation between fluctuation in attention and reactive aggression

Discussion

The goal of this study was to examine the executive dysfunctions underlying proactive and reactive aggression. To our knowledge, this study was one of the first to investigate these relations in a sample including a variation of boys with low to high aggression scores, in order to find evidence about general human mechanisms for different types of aggression in the population. Previous studies mainly examined clinical samples, suggesting executive dysfunctioning in boys with ODD and CD (e.g., Van Goozen et al., 2004). As hypothesized, multiple regression analyses indicated that the levels of both proactive and reactive aggression were significantly predicted by several executive functions. Some of the executive functions contributed to the prediction of both types of aggression; however we found unique factors for each type of aggression as well. The relevance and implications of our findings are discussed.

We have found that executive dysfunctions predict aggression in general, in accordance with Goldstein and colleagues (2007) and Lewis and colleagues (2008). These results are not only important for theoretical frameworks about the etiology of aggression, but for clinical purposes as well. We can underpin the importance of stimulating the development of efficient executive functions for the prevention and treatment of aggression, which could otherwise develop into antisocial behavior, disruptive behavior disorders (ODD and CD), antisocial personality disorder (ASPD), and delinquency and violence (Brendgen et al., 2001; Carlotta et al., 2011; Fite, et al., 2010; Scarpa et al., 2010; Vazsonyi et al., 2006; Vitaro et al., 1998). The executive functions develop during childhood and adolescence; therefore they are receptive to stimulation and change in these years (Diamond, 2002). The relevance of early identification of deficits in the executive functions is thereby supported. In order to identify which functions should be stimulated for the treatment of different types of aggression, we investigated similarities and differences in the mechanisms underlying these types. First, we elaborate on the executive functions that are found to predict both reactive and proactive aggression.

In accordance with findings from Dodge (2006) and Wilkowski and Robinson (2008) we have found that more errors in the inhibition task, i.e., low inhibition skills, predict higher rates of both reactive and proactive aggression. Inhibitory control represents the capacity to intentionally modify one’s behaviors when called upon to do so, and is thus important in behavioral control; this is impaired in aggressive individuals. It has been argued that aggressive behaviors in general are predicted by the deficiency in inhibitory processes; our study supports this assumption (e.g., Hobson, Scott, & Rubia, 2011). Inhibition processes can be considered one of the core aspects in treatment strategies that should be stimulated and improved for an efficient reduction or prevention of aggressive behaviors. Runions and Keating (2010) found a difference between proactive and reactive aggressors: deficits in response inhibition and planning ability were related primarily to reactive aggression. In contrast, we have found an association between inhibition problems and aggression in general. We have also found that reactive and proactive aggression are highly correlated; high scores on reactive aggression related to high scores on proactive aggression. Therefore, reactive aggression could mediate the relation between inhibition problems and proactive aggression. Potentially, the relation between inhibition and the proactive type of aggression would change or dissolve if it was controlled for reactive aggression. Our results could then be in line with findings by Runions and Keating.

Second, we elaborate on the differences we have found between mechanisms underlying the reactive and proactive types of aggression. We have found that higher planning ability (under structure) relates to more proactive aggression. Our results support findings from Blair (2003) who argued that proactive aggression was associated with anticipation and higher planning processes. The findings are also congruent with the theoretical designation of proactive aggression; which is referred to as premeditated, calculative, and controlled aggression, and we provide insight into the strong neurocognitive aspects in proactive aggressive boys (e.g., Kempes, et al., 2005; Ramirez & Andreu, 2006). A contrast is found with Hughes, White, Sharpen, and Dunn (2000), who evidenced that impairments in planning of behavior were related to more aggression in general. These discrepancies in results are potentially explained by a diversity of administration procedures of the planning tasks, or the specific operationalization of planning or the type of aggression. Planning ability can be examined in a structured or unstructured manner, by the generation of plans (Hughes, et al., 2000) or planning ability including visuo-motor control. These different operationalizations of planning ability provide data that are less comparable and they explain the variation in results between studies.

Another difference we have found between the mechanisms underlying reactive and proactive aggression is the contribution of the core executive functions: attention processes (Diamond, 2006). We have found that a lower fluctuation in speed of reaction – better attention – predicts higher scores of reactive aggression. Conner and colleagues (2003) found that reactive aggression was associated with increased problems in attention and impulsivity (also: Atkins & Stoff, 1993; Dodge, Lochman, Harnish, Bates, & Pettit, 1997). Our results are somewhat contradictive with previous studies: a lower fluctuation in speed of reaction is assumed a better sustained attention, and this was associated with more reactive aggression. The discrepancy could potentially be explained by the influence of inhibition and choice of strategy for the task. Reactive individuals encounter problems with inhibition and control of behavior, hence cannot suppress or inhibit themselves and slow down when they start making errors in the task; this leads to a rather constant high speed of reaction across the task. Responding at a constant pace due to inhibition problems could be a strategy in order to prevent oneself from missing any stimulus (Stanford, Greve, & Gerstle, 1997; Dodge, et al., 1997; Miller & Lynam, 2006). The results of the present study could not entirely support this assumption, due to inconsistent correlations among predictors, but some supported the suggestion that inhibition problems were indeed associated with low fluctuation in sustained attention. Another explanation is provided by the findings that reactive aggressive individuals react to perceive threats and experienced fear, which is related to their quick responses (Derryberry & Rothbart, 1997; Orobio de Castro, et al., 2002). Potentially, the reactive aggressive boys experienced fear or negative feelings toward missing stimuli, therefore they were hyper attentive and responded at a constant pace in the attention task: creating a low fluctuation in speed of reaction across the task.

Some of the executive functions investigated in this study were not significant individual predictors for either reactive or proactive aggression, but they contributed to the best predictive models for the types of aggression. Therefore these functions are discussed in the following section. Concerning the attention shifting process ‘cognitive flexibility’, we have found that this executive function (measured in errors) contributes to the predictive model of reactive aggression. Although the individual contribution was not significant, we decided to include the variable in the regression model, since exclusion resulted in a smaller proportion of variance explained in reactive aggression. In this model we have found that fewer errors in the cognitive flexibility task – i.e., better attention shifting – associate with more reactive aggression. However, in the literature it is discussed that the cognitive flexibility of reactive individuals is impaired (Kempes, Matthys, Maassen,Van Goozen, & Van Engeland, 2006). Rothbart (1989) argued that the ability to regulate internal emotional arousal involves attentional processes such as attention shifting. Reactive aggressive children are deficient in regulating their emotional arousal and experience deficits in switching attention between adequate behaviors and factors from the environment. An explanation for the discrepancy in findings is provided by the high correlation between reactive and proactive aggression in the present study. Proactive aggression is termed goal-oriented and controlled; therefore, it is possible that the attention shifting and regulation processes are better organized in these boys (Ramirez & Andreu, 2006; Vitiello & Stoff, 1997). The relation between cognitive flexibility and reactive aggression could be mediated by proactive aggression, and would potentially change or dissolve if it was controlled for proactive aggression. Our results could then support the previous literature.

The final function investigated was experienced frustration, i.e., the lack of frustration tolerance in the participants. As previously mentioned, the unique contribution of this predictor was also not significant, but it contributed to the best predictive model of proactive aggression. In this model we have found that higher frustration scores – i.e., lower tolerance – relate to higher proactive aggression scores. Vitaro, Brendgen, and Tremblay (2002) and Orobio de Castro and colleagues (2002) argued the relation between low frustration tolerance and reactive aggression, not proactive aggression. A limitation of our study could provide an explanation for this discrepancy: The Delay Frustration task from the ANT was administered during a stress protocol for participants in Leiden, but under normal circumstances in a cognition session in Amsterdam. It is expected that frustration scores increase under stressful circumstances; hence the scores of frustration could be influenced by the type of administration in the different research settings. This prevents us from drawing strong conclusions about the reliability of these results. Furthermore, the high correlation between proactive and reactive aggression could provide an explanation for the discrepancy in findings for this executive function as well. Reactive aggressive individuals are more impulsive and react to perceived threats or assaults; therefore it can be assumed that these individuals have quite low levels of frustration tolerance (Orobio de Castro, et al., 2002). In our study, the relation between frustration and proactive aggression could be mediated by reactive aggression, and would potentially change or dissolve if it was controlled for reactive aggression.

Other limitations of the present study are discussed in the following section, and explanations are provided. A possible clarification for some tendencies toward significance we have found, and for some results in contradiction with previous studies, is that we have not been able to create large enough sample sizes in order to draw strong conclusions on the available data, representative for the population. Since we have found tendencies toward significance with such a small sample, further research with larger sample sizes will most likely evidence the argued relations between deficits in executive functions and the types of aggression. It is therefore recommended to replicate our examined mechanisms underlying reactive and proactive aggression. Another characteristic of our study is that the sample consisted of participants from mainly the lower to average socioeconomic status (SES) of our society. This trait was not evenly distributed; presumably due to the bias we created by recruiting participants from certain urban areas. Cohen and colleagues (1998) found consistent relations between SES and aggression: a lower SES was related to higher aggression scores. Therefore, our sample including participants from mainly the lower SES of society was an adequate reflection of the population in which we wanted to examine mechanisms underlying aggression.

Another aspect of our study worth mentioning is the result of significant moderate to high correlations among some of the predictors. It could be argued that there are multicollinearity problems in the regression model for the prediction of reactive aggression, since the inhibition variable moderately to highly correlated with cognitive flexibility and sustained attention. This would imply that the regression model could only indicate how well the bundle of predictors predicted reactive aggression, but no strong conclusions could be drawn about the contribution of each predictor individually. We investigated the individual contributions of the predictors by excluding them from the regression model, and examine the changes in proportion of variance explained. Since we have found that the proportions of variance explained change by exclusion of the predictors, with a tendency toward significance, it is reasonable to argue that these executive functions have an individual contribution and should be included in the prediction of reactive aggression.

Apart from the previously mentioned recommendation of creating a larger sample, we discuss several other recommendations for future research. An interesting correlation brings evidence for an ongoing debate regarding the types of aggression: Reactive aggression was highly associated with proactive aggression. In previous studies some researchers suggested using a third combination group of proactive-reactive aggressors (Day, Bream, & Pal, 1992; Mayberry & Espelage, 2007; Polman, et al., 2009). In the literature, there is a debate regarding the utility of the distinction between reactive and proactive aggression (Bushman & Anderson, 2001). According to Poulain and Boivin (2000) and Baker and colleagues (2008) a two-factor model, with both the reactive and proactive aggressive groups, was more accurate than a one-dimensional model. The present study supports Polman and colleagues (2009) in using a combination group of proactive-reactive aggression. It seems best to acknowledge the existence of different functions of aggression, which could co-occur. Group comparisons between reactive, proactive and a combined aggression group are recommended to provide new insight into the differences of executive dysfunctions in these more specific types of aggression. In the present study such a comparison was not valid, for we had too few participants that scored high on only one type of aggression, but we provide the basis of the executive dysfunctions that predict the two types of aggression. Furthermore, as discussed earlier, the high correlation between the two types of aggression could explain why some of our results contrasted previous literature: the several relations between executive functions and one type of aggression could change or dissolve after controlling for the other type of aggression. Future research with different aggression groups, including a combination group, could clarify which executive functions specifically predict the types of aggression, and provide explanations for the discrepancies we found in the present study. Furthermore, it is recommended to investigate the relation between frustration tolerance and the types of aggression more specifically with the use of standardized settings for all participants, since we included two different settings in Leiden and Amsterdam. The implications of knowledge about the regulation of frustration and its relation with the development of aggressive behaviors are of great extent for creating prevention and intervention programs. Previous studies found significant contributions of frustration to the display of aggression while playing games (Carlotta et al., 2011; Fling, et al., 1992), and it is important to understand these relations in daily life which also comprises unexpected stressful events. If the relations are established, treatment strategies should focus on these aspects in children who experience problems in the tolerance of frustration and the control of their behavior to prevent them from developing extensive aggressive behavior (Brendgen et al., 2001). Future research is also required to investigate the assumption that inhibitory control processes influence the fluctuation in speed of reaction in tasks that are measuring attention processes. A possible moderation effect of inhibition on the relation between attention processes and aggression could be investigated. To develop effective treatment strategies, it is relevant to examine whether the attention processes are indeed impaired in different types of aggression, or whether this executive function is potentially not the core mechanism for the display of aggressive behaviors.

To conclude, this study has provided evidence for several executive functions as mechanisms underlying reactive and proactive aggression. Both similarities and differences are found in the predictors of the different types of aggression. Furthermore, we have established a high relation between reactive and proactive aggression, which indicates a co-occurrence of the two types in several individuals. We provide a basis of the mechanisms underlying types of aggression, but future research is required to identify the specific executive functions leading towards either reactive, proactive or a combined-aggression type. The present and future studies concerning these neurocognitive mechanisms of aggression can underpin the importance and usefulness of knowledge about relations toward aggressive behavior, in order to provide core aspects for prevention and intervention programs for the boys with sincere problems in cognitive, social, and behavioral development.

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