

# Executive Functioning and Non-Verbal Intelligence as Predictors of Bullying in Early Elementary School

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**Abstract** Executive function and intelligence are negatively associated with aggression, yet the role of executive function has rarely been examined in the context of school bullying. We studied whether different domains of executive function and non-verbal intelligence are associated with bullying involvement in early elementary school. The association was examined in a population-based sample of 1,377 children. At age 4 years we assessed problems in inhibition, shifting, emotional control, working memory and planning/organization, using a validated parental questionnaire (the

BRIEF-P). Additionally, we determined child non-verbal IQ at age 6 years. Bullying involvement as a bully, victim or a bully-victim in grades 1–2 of elementary school (mean age 7.7 years) was measured using a peer-nomination procedure. Individual bullying scores were based on the ratings by multiple peers (on average 20 classmates). Analyses were adjusted for various child and maternal socio-demographic and psychosocial covariates. Child score for inhibition problems was associated with the risk of being a bully ( $OR$  per  $SD=1.35$ ,  $95\%CI$ : 1.09–1.66), victim ( $OR$  per  $SD=1.21$ ,  $95\%CI$ : 1.00–1.45) and a bully-victim ( $OR$  per  $SD=1.55$ ,  $95\%CI$ : 1.10–2.17). Children with higher non-verbal IQ were less likely to be victims ( $OR=0.99$ ,  $95\%CI$ : 0.98–1.00) and bully-victims ( $OR=95\%CI$ : 0.93–0.98, respectively). In conclusion, our study showed that peer interactions may be to some extent influenced by children’s executive function and non-verbal intelligence. Future studies should examine whether training executive function skills can reduce bullying involvement and improve the quality of peer relationships.

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## Abbreviations

OR Odds ratio  
CI Confidence interval  
BRIEF-P Behavior rating inventory of executive function-preschool version  
CBCL Child behavior checklist  
PEERS Peer evaluation of relationships at school

## Bullying Involvement

Bullying, which is typically defined as intentional and continuous peer aggression involving power imbalance between the victim and aggressor (Olweus 1993), is already common at the start of elementary school. About one-third of young elementary school children experience bullying either as a bully, victim or a bully-victim (Jansen et al. 2012). School bullying negatively affects health and development of both bullies and victims. Studies show that bullying involvement is associated with various short- and long-term consequences such as psychological distress, internalizing and externalizing problems (Arseneault et al. 2006), anxiety and depression (Arseneault et al. 2010), borderline personality and psychotic symptoms (Schreier et al. 2009; Wolke et al. 2012), self-harm (Fisher et al. 2012) and suicidal ideation (Winsper et al. 2012).

Several bullying involvement roles are typically defined: bully, victim, bully-victim, reinforcer, assistant, defender and outsider (Salmivalli et al. 1996). The roles of a bully, victim and a bully-victim are the most salient; these children are directly involved in bullying and are at higher risk of negative health outcomes. Victims are typically described as submissive, insecure children (Salmivalli and Peets 2009), who are characterized by increased symptoms of anxiety, depression, low self-esteem and poor social skills (Arseneault et al. 2010). Bullies and bully-victims can be best described in terms of the concepts of proactive and reactive aggression (Dodge and Coie 1987). Bullies are mostly proactively aggressive children (Camodeca and Goossens 2005; Salmivalli and Nieminen 2002), who favor the use of aggression as an effective instrument in goal achievement (Salmivalli and Peets 2009). Bully-victims<sup>1</sup> are typically described as very aggressive and disruptive (Salmivalli and Peets 2009) as well as anxious, emotional and hot-tempered (Olweus 1993; Schwartz et al. 1998). Importantly, bully-victims are the most aggressive group of all children involved in bullying and they demonstrate the highest levels of both proactive and reactive aggression (Salmivalli and Nieminen 2002). Compared to bullies and victims, the bully-victims stand-out as a group of children most at risk of developing multiple psychopathologic behaviors (Kim et al. 2006), and they are most likely to remain involved in bullying for prolonged periods of time (Kumpulainen et al. 1999).

## Executive Function, Social Cognitions and Intelligence

Aggression and behavioral problems tend to manifest more often in children with impaired cognitive skills. For instance, intelligence has been indicated to be one of the cognitive

<sup>1</sup> This group is also often referred to as “reactive victims” or “aggressive victims”.

correlates of aggression. A negative relation between IQ and delinquency has been well established (Fergusson and Horwood 1995; Hirschi and Hindelang 1977; Lynam et al. 1993; Moffitt et al. 1981). Similarly, it was shown that IQ correlates negatively with aggressive behavior and conduct problems (Huesmann and Eron 1984; Huesmann et al. 1987; Rutter et al. 2008). Importantly, low IQ exerts most of its effect on early aggression with an onset before age 8 years, and that, in its turn, has implications for child’s later intellectual achievement and aggression at later age (Huesmann et al. 1987).

Besides the intellectual abilities, other cognitive skills have been related to aggression. Several studies reported a relation between aggression and poor higher cognitive abilities that are often referred to as executive function (Séguin et al. 1999; 1995; Séguin and Zelazo 2005). Executive function (or conscious control of thought, action and emotion) commonly refers to the self-regulation mechanisms involved in goal-setting and problem-solving processes (Séguin and Zelazo 2005; Zelazo et al. 2003). These are, for instance, the ability to inhibit behavior, control emotions, plan and organize thoughts and actions. A problem-solving framework proposed by Zelazo and colleagues (Zelazo et al. 1997) identifies four sequential phases of executive function: problem representation, planning, execution and evaluation. Séguin and Zelazo (2005) argue that this framework allows us understand why and at what phase children fail to regulate their physical aggression. Executive function failures at one or several of these phases during peer interactions may set the stage for peer problems. For example, children may fail to represent a problem adequately, or they may be unable to plan and think ahead; children may understand the rules but fail to use these rules, or they may have difficulties evaluating their actions and its impact on others (Séguin and Zelazo 2005). In addition, at some of these phases, for instance during the problem representation, other cognitive mechanisms, for example children’s misconceptions or perception biases, may also play an important role.

The social information-processing approach emphasizes the role of perception biases as triggers of aggression. According to this theoretical model (Crick and Dodge 1994), aggression can be explained by deficiencies in the social cognitions that are required for solving social problems. Following the social information-processing model, behavior of a child, for instance during a peer conflict, is guided by a chain of thought processes which can be summarized in six sequential steps: perception of external and internal cues, interpretation of these cues, setting the goals, generating possible responses, evaluating and selecting a response, and taking an action and evaluating the chosen response (Crick and Dodge 1994; Rutter et al. 2008). According to this approach, deficits in information processing at one or more of these steps may trigger social adjustment problems in children.

## Executive Function and Adjustment Problems in Childhood

As Salmivalli and Peets pointed out, bullying is a group process that depends on *group norms*, and it is often used to achieve or maintain *social status in a peer group* (Salmivalli and Peets 2009). Bullying can be used to achieve an individual goal, such as power, respect or high social status within a peer group; or it may be used to protect the group's norms, for example by socially excluding unpopular peers to maintain the group's popularity status (Salmivalli and Peets 2009). Importantly, in order to achieve a goal, for instance a high social status, different children may behave differently (e.g., prosocially vs. aggressively) and use different strategies, depending on their cognitions and beliefs.

However, not all peer aggression is instrumental and proactive. Many children often demonstrate reactive forms of peer aggression (Price and Dodge 1989). In fact, comparison of children's different bullying involvement roles demonstrated that bullies, victims and bully-victims all show at least some reactive aggression (Salmivalli and Nieminen 2002). Importantly, this indicates that the victim group should not be considered as completely non-aggressive. Victims score higher on reactive aggression compared to control children, however, victims are not proactively aggressive and they are much less reactively aggressive than bullies and bully-victims (Salmivalli and Nieminen 2002). Bullies are more proactively and reactively aggressive than victims and controls, however bullies are less aggressive than bully-victims. Finally, the bully-victims have the highest levels of both proactive and reactive aggression (Salmivalli and Nieminen 2002).

Some studies suggested that bully-victims are more likely to demonstrate reactive aggression as a result of having difficulties regulating their behavior (Schwartz 2000; Toblin et al. 2005). Bully-victims are often described as impulsive, inattentive and hyperactive (Schwartz 2000; Toblin et al. 2005). These characteristics could signal co-occurring behavioral problems, such as ADHD. Several studies that examined bullying and victimization experiences of children with ADHD (Holmberg and Hjern 2008; Kumpulainen et al. 2001; Shea and Wiener 2003; Timmermanis and Wiener 2011; Unnever and Cornell 2003; Wiener and Mak 2009) found that ADHD symptoms and low self-control of these children are potential risk factors for bullying and for victimization. Yet, it remains unclear to what extent self-regulation problems are associated with bullying and victimization in children without ADHD symptoms.

An association between executive function and aggressive behavior of young children has been reported in several studies. Hughes and colleagues observed preschoolers play with peers and reported that the angry and antisocial behaviors are associated with children's poor executive control, namely poor performance on inhibitory control and planning tasks

(Hughes et al. 2000). Children with poor inhibitory control often demonstrate such behaviors as "inappropriate physical responses to others and a tendency to interrupt and disrupt group activities" (Gioia et al. 2003, p. 17). Other studies that examined executive function in preschool and school-aged children also reported an association between poor inhibition skills and aggression (Raaijmakers et al. 2008), and between poor inhibition and planning ability and reactive aggression (Ellis et al. 2009). Similarly, the performance of peer-reported aggressors on inhibition and planning tasks was reported to be rather poor (Monks et al. 2005). Furthermore, planning/organizing and metacognition (i.e., learning, memory) were reported to be associated with bullying (Coolidge et al. 2004), and working memory was shown to be related to physical aggression, even after adjustment for ADHD and IQ (Séguin et al. 1999). Similar evidence can be found in studies of social information-processing. For instance, Crick and Dodge (1994), suggested that maladjusted children may have memory deficits that impair storing or accurately remembering social information, and that socially maladjusted children may have difficulties remembering appropriate social responses or may have cognitive difficulties with constructing new social responses. Also, some findings indicate that executive function skills may interact with children's social information-processing. For instance, Ellis et al. (2009) found that hostile attributional biases moderated the association between children's planning ability and aggression. They have also found that encoding of hostile cues moderated the relation between inhibition and reactive aggression. Similarly, in a study of Carlson et al. (2002) an attribution of a mistaken belief correlated with inhibitory control (Carlson et al. 2002).

Social-cognitive impairments of bullies, victims and aggressive victims<sup>2</sup> (i.e., a group of victimized children who demonstrate high levels of reactive aggression) have been described in several studies (Camodeca and Goossens 2005; Schwartz 2000; Toblin et al. 2005). In one of these studies it was found that bullies and victims differ from their peers in almost all of the steps of social information-processing (Camodeca and Goossens 2005). It was concluded that bullies and victims are similar to each other with respect to their reactive aggression and their social-information processing. This suggests that both bullies and victims may have similar social-cognitive deficits.

<sup>2</sup> To be consistent in the use of terminology in our manuscript, we will use the concept of "bully-victim" when referring to children who are both victims and bullies, as characteristics of bully-victims come close to the characteristics of the group of children described as "reactive victims" and "aggressive victims" in the social information-processing studies. However, the degree of correspondence between these groups is most probably not complete.

## Current Study

While it is clear from the studies of social information-processing that social-cognitive biases may predispose children to bullying involvement (e.g., through hostile attributional biases or selective attention to aggressive cues), little is known about the role of executive function as a self-regulation mechanism in bullying and victimization. Are children who fail to regulate their thoughts and behavior more likely to become involved in bullying? Given the findings from previous studies on aggression, it can be assumed that the self-control difficulties may (possibly together with cognitive biases) predispose a child to bullying involvement.

In this prospective study we examine the executive function of bullies, victims and bully-victims. We investigate which domains of executive function (inhibition, shifting, emotional control, working memory or planning/organization) are associated with being a bully, victim or a bully-victim.

Based on studies suggesting a relation between executive function and aggression, we expected that poor executive function would be associated with bullying involvement. Earlier studies have shown a relation between aggression (mainly reactive) and poor inhibition, planning/organization and working memory (Coolidge et al. 2004; Ellis et al. 2009; Raaijmakers et al. 2008; Séguin et al. 1999). Considering that bullies and bully-victims are both reactively and proactively aggressive, and victims are primarily reactively aggressive (Camodeca et al. 2002; Salmivalli and Nieminen 2002), we expected that poor executive function would be associated with bullying and victimization. More specifically, the impulsive behavioral style of a child with inhibition problems, such as inappropriate physical responses and disruptive activities in the group, can be perceived by peers as bullying. At the same time, such behavioral style might trigger aggression as a reaction of the peers to the inappropriate behavior of the child. In this way, inhibition problems may predispose a child to victimization, as it is often described in studies of children with ADHD symptoms. Alternatively, inhibition problems may result in a failure to inhibit anxious thoughts, which, in its turn, could make a child more vulnerable to victimization. Thus, we expected that children with inhibition problems would be more likely to be involved in bullying either as bullies, victims or bully-victims.

As described in earlier studies, working memory and planning/organization problems of aggressive children may reflect children's difficulties to remember the appropriate social response strategies or to construct new alternative strategies. Children with such problems may also have difficulties with thinking and planning ahead, or anticipating the negative consequences of their behavioral strategy (Séguin and Zelazo 2005). This suggests that aggressive behavior of bullies and bully-victims could be associated with their poor working

memory and planning/organization skills. We have put this hypothesis to a test by examining the risks of being a bully or a bully-victim in children with poor working memory and poor planning/organization skills.

In sum, we examine whether children's poor executive function, assessed at preschool age, is associated with the peer/self-reported bullying involvement in the first grades of elementary school. We studied this in a large population-based sample while accounting for possible influences of various child and maternal socio-demographic and psychosocial factors. Considering that child IQ is related to early aggression, we examined the effects of IQ on bullying. Additionally, we examined whether IQ did not confound an association between executive function and bullying involvement. Even though intelligence is often described as being independent of executive function (Pennington and Ozonoff 1996), IQ is related to aggression and to executive function (IQ scores share variance with measures of executive function), and thus it could confound the studied association. Finally, we examined whether our results are not confounded by children's co-occurring behavioral problems, namely ADHD symptoms, which were shown to be associated with both children's executive function and with bullying involvement.

## Methods

### Participants and Study Design

Thirty-seven elementary schools, with a total of 190 classes, in Rotterdam, the Netherlands participated in the PEERS study assessing children's bullying involvement. Parents of the children from the participating schools were informed about the study by mail and booklets that were distributed to them via teachers. Parents, who did not want their child to participate, were asked to inform a teacher or a researcher before the assessment. In total, 4,017 children participated in the study (participation rate: 98 %, see Appendix 1 for a flowchart of the sampling procedure). The PEERS assessment was approved by the Medical Ethics Committee of the Erasmus Medical Centre, Rotterdam the Netherlands (MEC-2010-230).

The present study is embedded in the Generation R Study (Jaddoe et al. 2012), a large population-based prospective cohort from fetal life onwards in Rotterdam, the Netherlands. Mothers living in Rotterdam with a delivery date between April 2002 and January 2006, were enrolled in the Generation R Study. Parents of all participants provided written informed consent. The Generation R Study was approved by the Medical Ethics Committee of the Erasmus Medical Centre. Regular extensive assessments have been carried out in children and parents (Tiemeier et al. 2012). The PEERS-data were collected at the time when the oldest Generation R participants were in grades 1–2 of elementary school. Prior to the start of

the Generation R phase 3 (from age 5 years onwards), written permission to merge data of the Generation R Study from schools and registries was requested from parents of children participating in the Generation R Study (MEC 2007-413). Out of 4,017 children who completed the PEERS Measure parents of 1,664 provided consent for participation in at least one of the data collection phases of the Generation R Study in the period between birth and 5 years. Of the 1,664 children, 1,590 children provided consent for data linkage at age 5 years and onwards. The analyses for the present study were performed in 1,377 children for whom data on bullying involvement and either executive functioning or IQ was available.

### Bullying and Victimization

Peer victimization was assessed in elementary school children at grades 1–2 (mean age 7.68 years,  $SD=9.12$  months) using the PEERS Measure (Verlinden et al. 2013). The PEERS Measure is an interactive computerized instrument that offers a reliable and age-appropriate method of using peer nominations with young children.

Children received instructions from a trained researcher and then completed the assessment independently. Bullying was explained to children as intentional, repeated and continuous actions of peer aggression where victim finds it difficult to defend him/herself (Olweus 1993). An age appropriate explanation and examples of both bullying and non-bullying behaviors were provided (Verlinden et al. 2013). Four different forms of victimization were assessed: physical (e.g., hitting, kicking, pushing), verbal (e.g., saying mean or ugly things, calling names, teasing), relational (e.g., excluding, leaving out of games) and material (e.g., taking away, breaking or hiding belongings). Children listened to the audio instructions and questions that were accompanied by visual illustrations. Four yes/no questions, each about a different form of victimization, preceded the peer nominations. If a question was answered affirmatively, a child was asked to nominate those classmates who bullied him/her. For instance, to assess physical victimization, children were shown a picture depicting physical bullying, accompanied by an audio explanation of the depicted behavior. Subsequently, children were asked whether their classmates behaved that way towards them, (i.e., often hit, kicked or pushed them). If such question was answered affirmatively, children could click on the photos of the classmates to nominate the children who bullied them.

For each of the bullying questions children received an individual score that was based on the ratings by multiple peers. Considering that a school class consisted on average of 21 children, each child was rated by about 20 classmates with regards to each bullying question. The number of nominations a child gave to the classmates when indicating his/her aggressor(s) was used to calculate individual victimization scores.

The number of nominations a child received from the classmates as a bully was used to calculate individual bullying scores. The proportion scores were derived by division of the given/received nominations by the number of children performing the evaluation. Higher scores reflected more bullying or victimization nominations. The scores of four bullying and four victimization questions were averaged to obtain the overall bullying and victimization scores.

Considering that the group of bully-victims is the most problematic group of children among those involved in bullying (Kim et al. 2006; Salmivalli and Nieminen 2002), we studied children's bullying involvement by categorizing them in different groups. To define the specific bullying involvement roles (i.e., bully, victim and bully-victim), we dichotomized the continuous bullying and victimization scores using the top 25th percentile as cut-off in the sample of all children who were assessed using the PEERS Measure. This cut-off was applied in earlier studies that used a peer-nomination method (Demaray and Malecki 2003; Veenstra et al. 2005). The resulting dichotomized measures were then used to categorize children into four non-overlapping groups: uninvolved, bullies, victims and bully-victims.

### Executive Function and Non-Verbal IQ

Executive function was assessed in children at the mean age of 4.1 years ( $SD=1.2$  months) using parental questionnaire, the Behavior Rating Inventory of Executive Function-Preschool Version (BRIEF-P) (Gioia et al. 2003). The BRIEF-P is a 63-item questionnaire that assesses different aspects of executive function in preschool children. Parents were asked to report the extent to which their child displayed different behaviors related to executive function within the last month, using answer categories: "Never or not at all", "Sometimes or a little", "Often or clearly". Five empirically derived scales were used to measure children's abilities with respect to the following aspects of executive functioning: (1) inhibition, 16 items assessing child's ability not to act upon impulse (e.g., "Is impulsive"); (2) shifting, 10 items measuring rigidity or inflexibility (e.g., "Has trouble changing activities"); (3) emotional control, 10 items assessing emotional responses to seemingly minor events (e.g., "Mood changes frequently"); (4) working memory, 17 items measuring ability to hold information in mind for the purpose of completing a task (e.g., "Is unaware when he/she performs a task right or wrong"); (5) planning/organization, 10 items assessing ability to anticipate future events and bring order to information, actions or materials in order to achieve a goal (e.g., "Has trouble following established routines for sleeping, eating, or play activities"). The Global Executive Composite (a sum score of the five clinical scales) is a total measure of the executive function. Higher scores on BRIEF-P scales indicate more executive function problems.

Good test-retest reliability and content validity of the BRIEF-P were demonstrated in earlier research (Sherman and Brooks 2010). In our data, the reliability of the BRIEF-P scales was: 0.88 for inhibition, 0.81 for shifting, 0.84 for emotional control, 0.89 for working memory scale, 0.78 for planning/organization problems scale and 0.95 for the global executive composite scale.

The BRIEF-P is a behavioral measure of executive function. The rating measure of executive function, such as the BRIEF-P, assesses the extent to which children are capable of a goal pursuit and achievement of a goal, while the performance-based measures of executive function reflect children's processing efficiency of cognitive abilities (Toplak et al. 2013). According to Toplak et al. (2013) both types of measures provide valuable information assessing different aspects of cognitive and behavioral functioning.

An observational measure was used to assess IQ of the children at mean age 6.0 years ( $SD=3.48$  months). Children's non-verbal intellectual abilities were measured using two subtests of a Dutch IQ test: Snijders-Oomen Niet-verbale intelligentie Test–Revisie (SON-R 2½-7) (Tellegen et al. 2005). The following test subsets were used as a measure of non-verbal intelligence: Mosaics (assesses spatial visualization abilities of children), and Categories (assesses abstract reasoning abilities in children). Raw scores were derived from these two subtests. The raw scores of each subtest were standardized to reflect a mean and standard deviation of the Dutch norm population age 2½ - 7 years. The sum of the standardized scores of the two subtests were converted into SON-R IQ score using age-specific reference scores provided in the SON-R 2½ - 7 manual (mean=100,  $SD=15$ ). The use of the subsets is warranted as the correlation between the IQ scores based on the two subtests and the full SON-R IQ battery was high ( $r=0.86$ , Tellegen, personal communication). The average reliability of the SON-R 2½ - 7 IQ score is 0.90, range 0.86–0.92 for the respective age (Tellegen et al. 2005). The reliability of the subtests that were used in our study are: 0.73 for Mosaics and 0.71 for Categories.

#### Covariates

Based on previous studies of executive function, we adjusted our analyses for the following socio-demographic and psychosocial covariates: child age, gender and national origin, attention deficit/hyperactivity problems, internalizing problems, maternal age and national origin, birth order (parity), educational level, monthly household income, marital status, depression symptoms and parenting stress (Dietz et al. 1997; Isquith et al. 2004; Rubin et al. 2009). Information about children's date of birth and gender were obtained from midwives and hospital registries. All other covariates were assessed using parental questionnaires. National origin of a child was defined by country of birth of the parent(s) and

categorized as Dutch, Other Western or Non-Western (Statistics Netherlands 2004a).

Children's Attention Deficit/Hyperactivity Problems and Internalizing Problems at 36 months were reported by parents using the Dutch version of the Child Behavior Checklist, CBCL1½-5 (Achenbach and Rescorla 2000; Tick et al. 2007). Examples of the DSM-oriented Attention Deficit/Hyperactivity Problems scale are: "Cannot concentrate, cannot pay attention for long", and "Cannot sit still, restless, or hyperactive". The Internalizing scale consists of four syndrome scales: emotionally reactive (e.g., "Worries"), anxious depressed (e.g., "Fearful"), withdrawn (e.g., "Little affection") and somatic complaints (e.g., "Aches"). All items were rated on a 3-point Likert scale. The CBCL1½-5 has good validity and reliability (Achenbach and Rescorla 2000; Tick et al. 2007). The reliability of the behavioral problems scales in our sample was 0.75 for Attention Deficit/Hyperactivity Problems and 0.82 for Internalizing Problems.

Birth order of the child (i.e., parity) was categorized as: "No older sibling in family" and "Older sibling(s) in family". The highest attained educational level of the mother (4 categories) ranged from "Low" (<3 years of general secondary education) to "High" (higher academic education/PhD) (Statistics Netherlands 2004b). Marital status was categorized as: "Married/living together" and "Single". The net monthly household income comprised the categories: "Less than €1,200" (below social security level), "€1,200 to €2,000" (modal income), and "More than €2,000" (above modal income).

Maternal depression symptoms were assessed when children were 3 years old using the Brief Symptom Inventory, a validated instrument containing 53 self-appraisal statements (Derogatis 1993). A continuous scale consisting of 6 items was used in the analysis, with higher scores representing more symptoms of depression. Cronbach's  $\alpha$  for items measuring depression was 0.99. Parenting stress was assessed when children were 18 months old, using the Nijmeegse Ouderlijke Stress Index–Kort (De Brock et al. 1992), a questionnaire consisting of 25 items on parenting stress related to parent and child factors. Cronbach's  $\alpha$  for the parenting stress scale was 0.72. The sum scores of the measures were used in the analyses.

#### Statistical Analysis

We examined whether different domains of child executive function and its overall composite score and child IQ were associated with the risk of being a bully, victim or a bully-victim (reference group: uninvolved). For our main analyses, two multilevel logistic regression models were analyzed: a univariate model and a model adjusted for socio-demographic and psychosocial covariates (Tables 2, 3, and 4).

In additional analyses, the association between executive function and bullying involvement was additionally adjusted for IQ to examine whether any effect of executive function was independent of IQ. To this aim, we added IQ as a covariate to the adjusted models presented in Tables 2, 3, and 4. Likewise, all analyses of executive function and bullying involvement were additionally adjusted for ADHD symptoms. The aim of this analysis was to test whether ADHD symptoms underlie the observed association. To adjust for the ADHD problems we added the scores of the CBCL DSM-oriented Attention Deficit/Hyperactivity Problems scale to the adjusted models presented in Tables 2, 3, and 4.

The scores of the BRIEF-P scales were *SD*-standardized (scores were divided by standard deviations), thus the effect estimates can be interpreted as an increase in odds of bullying involvement per standard deviation increase in problems on executive function scale. In order to confirm the consistency of the findings obtained using the categorical measure of bullying involvement, we additionally performed the same analyses using the continuous scales of bullying and victimization.

Missing data were estimated using multiple imputation technique (chained equations using STATA) (Stata/SE 12.0, StataCorp LP Texas). All covariates were used to estimate the missing values and the reported effect estimates are the product of the pooled results. In order to account for the clustered structure of the data (i.e., on average six children from the same school classes were included in the analyses), we performed multilevel regression analyses using school class as a grouping variable.

#### Non-Response Analyses

Our study sample included the Generation R Study participants with the peer/self-reports of bullying involvement ( $N=1,552$ ) for whom data on at least one of the five BRIEF-P scales or the IQ measure were available ( $n=1,377$ ). These 1,377 children were compared to those with missing data on all the BRIEF-P scales and IQ ( $n=175$ ). Data were missing more often in children of non-Western national origin (16.1 % vs. 6.3 %,  $p<0.001$ ). Mothers of children with missing data were on average younger (mean difference 2.6 years,  $p<0.001$ ) more often lower educated (12.9 % vs. 4.8 %,  $p<0.001$ ), and more often single (16.5 % vs. 7.8 %,  $p=0.001$ ).

## Results

#### Sample Characteristics

Child and maternal characteristics are presented in Table 1. Bullying and victimization were assessed at the mean age of 7.68 years ( $SD=9.12$  months). Our sample comprised 48.3 % of boys, and 59.6 % of children of Dutch national origin.

Sixty-seven percent of children were categorized as uninvolved in bullying, 11.8 % as bullies, 14.1 % as victims and 7.3 % as bully-victims.

#### Executive Functioning and Bullying Involvement

We examined whether child executive function problems in areas of inhibition, shifting, emotional control, working memory or planning/organization were associated with bullying involvement in early elementary school. We analyzed the risks of bullying involvement for each outcome separately: bully, victim, and bully-victim (reference group: uninvolved). Adjustment of the analyses for the child and maternal covariates attenuated some of the effect estimates (Tables 2, 3, and 4). For reasons of brevity, we discuss only the results obtained from the adjusted analyses.

First, we studied the association of executive function and child IQ with a risk of being a bully. As shown in Table 2, the risk of being a bully was higher in children with inhibition problems ( $OR$  per  $SD=1.35$ ,  $95\%CI$ : 1.09–1.66). The effects of working memory were marginally significant ( $OR$  per  $SD=1.29$ ,  $95\%CI$ : 0.97–1.72). Next, we examined the association between executive functioning and the risk of being a victim (Table 3). *Peer victimization* was predicted by inhibition problem score ( $OR$  per  $SD=1.21$ ,  $95\%CI$ : 1.00–1.45). None of the other domains of executive function were associated with peer victimization after adjustment for the covariates. Child IQ was related to a lower risk of victimization ( $OR=0.99$  per  $SD$ ,  $95\%CI$ : 0.98–1.00). The risks of being a bully-victim in relation to child's executive function are presented in Table 4. Children with inhibition problems showed an increased risk of being a bully-victim ( $OR$  per  $SD=1.55$ ,  $95\%CI$ : 1.10–2.17). Also, children with higher IQ scores were less likely to be a bully-victim ( $OR=0.95$ ,  $95\%CI$ : 0.93–0.98).

In additional analyses we examined whether the association between executive function and bullying involvement is independent of child IQ and ADHD problems. Additional adjustment of the association between executive function and bullying involvement for non-verbal IQ yielded essentially identical results to those presented above. For example, the additional IQ adjustment of the association between inhibition problems and risk of being a bully resulted into  $OR$  per  $SD=1.34$ ,  $95\%CI$ : 1.09–1.65 (other data not presented). This demonstrates that the association between child executive function and bullying involvement is mostly independent of child non-verbal IQ. An additional adjustment of the association between executive function and bullying involvement for ADHD symptoms only marginally changed our results. For example, effects of inhibition problems became:  $OR$  bully per  $SD=1.39$ ,  $95\%CI$ : 1.10–1.77;  $OR$  victim per  $SD=1.17$ ,  $95\%CI$ : 0.95–1.45, and  $OR$  bully-victim per  $SD=1.47$ ,  $95\%CI$ : 1.01–2.13 (other data not presented).

**Table 1** Sample characteristics

Child characteristics	<i>N</i>	<i>M</i> ( <i>SD</i> ) <sup>a</sup>	Min – Max
Age child, y	1,377	7.68 (9.12)	5.75–9.88
Gender (boys, %)	1,377	48.3	
National origin (%)			
Dutch	821	59.6	
Other Western	149	10.8	
Non-western	375	27.2	
Bullying involvement <sup>b</sup> (%)			
Uninvolved	920	66.8	
Bully	163	11.8	
Victim	194	14.1	
Bully-victim	100	7.3	
Executive function problems <sup>c</sup> (total score on BRIEF-P)	1,045	85.20 (15.16)	63–147
Inhibition problem score	1,039	22.16 (4.99)	16–42
Shifting problem score	1,052	13.61 (3.22)	10–30
Emotional control problem score	1,052	14.25 (3.38)	10–27
Working memory problem score	1,042	21.53 (4.61)	17–39.31
Planning/organization problem score	1,050	13.65 (2.96)	10–25.56
Internalizing problems <sup>d</sup>	1,014	4.86 (4.70)	0–36
Externalizing problems <sup>d</sup>	1,013	7.94 (5.91)	0–40
Attention deficit/hyperactivity problems	1,017	2.75 (2.21)	0–12
IQ score <sup>e</sup>	1,201	101.94 (14.62)	55–147
Maternal characteristics			
Age mother (at intake), y	1,377	31.65 (4.61)	15.35–46.34
National origin (%)			
Dutch	796	57.8	
Other Western	183	13.29	
Non-western	366	26.58	
Educational level (%)			
Low	193	15.2	
Mid-low	382	30.2	
Mid-high	320	25.3	
High	371	29.3	
Monthly household income (%)			
Less than €1,200 (approximately US \$1,500)	156	14.2	
€1,200 to €2,000 (approximately US \$1,500–\$2,500)	190	17.3	
More than €2,000 (approximately US \$2,500)	750	68.4	
Maternal marital status (single, %)	1,265	10.4	
Maternal depression symptoms <sup>f</sup>	1,009	0.13 (0.32)	0–2.67
Parenting stress <sup>g</sup>	1,025	0.32 (0.29)	0–2.45
Older sibling(s) in family (%)	1,377	46.91	

<sup>a</sup> Unless otherwise indicated

<sup>b</sup> Bullying involvement was assessed at age 8 years using the PEERS Measure

<sup>c</sup> Executive functioning was assessed at age 4 years with the BRIEF-P, the Behaviour Rating Inventory of Executive Function-Preschool Version

<sup>d</sup> Behavioral problems were assessed at age 3 years with CBCL/1½-5, the Dutch version of the Child Behaviour Checklist

<sup>e</sup> Non-verbal intellectual abilities were assessed at age 5 years using two subtests of a Dutch IQ test: Snijders-Oomen Niet-verbale intelligentie Test–Revisie (SON-R 2½-7)

<sup>f</sup> Depression symptoms were measured with the Brief Symptom Inventory

<sup>g</sup> Parenting stress was measured by Nijmeegse Ouderlijk Stress Index—Kort

Finally, we performed the same analyses using continuous measures of bullying and victimization. The results obtained for bullying and victimization scales were in line with those obtained from the analyses using categorical measures (see supplementary Tables 1–2), with the exception of the effects of working memory and IQ on bullying, which remained statistically significant in the fully adjusted model (supplementary Table 1). The coefficients in these additional analyses

represent unstandardized betas. Furthermore, the BRIEF-P scales were *SD*-standardized and bullying and victimization scales were transformed using square root transformation to normalize the distribution. In the continuous analyses it was not possible to distinguish the group of bully-victims; therefore the results of the continuous analyses for bullies and victims partly reflect the risk associated with being a bully-victim.



**Table 2** Child executive functioning and bullying in early elementary school (*n*=1,083)

Executive functioning	Risk of being a bully			
	Univariate model		Adjusted for covariates <sup>a</sup>	
	<i>OR</i> (95 % <i>CI</i> )	<i>p</i> -value	<i>OR</i> (95 % <i>CI</i> )	<i>p</i> -value
Domains of executive functioning (per <i>SD</i> )				
Inhibition problem score	1.52 (1.25–1.84)	<0.001	1.35 (1.09–1.66)	0.005
Shifting problem score	1.02 (0.80–1.30)	0.86	0.94 (0.72–1.22)	0.61
Emotional control problem score	1.13 (0.93–1.38)	0.22	1.05 (0.84–1.32)	0.64
Working memory problem score	1.45 (1.14–1.84)	0.004	1.29 (0.97–1.72)	0.08
Planning/organization problem score	1.24 (0.96–1.60)	0.10	1.10 (0.86–1.41)	0.45
Global scores				
Global executive composite (per <i>SD</i> )	1.45 (1.16–1.80)	0.001	1.24 (0.97–1.60)	0.09
Child IQ score	0.98 (0.97–0.99)	0.006	0.99 (0.97–1.00)	0.16

Analyses were conducted in 1,083 of 1,377 children ('uninvolved' *n*= 920, 'bully' *n*=163), children categorized as 'victim' (*n*=194) and 'bully-victim' (*n*=100) were not included in this analysis

Bullying is peer-reported. Peer nomination scores were based on ratings by multiple peers. Higher scores on BRIEF-P subscales denote more problems

<sup>a</sup> Adjusted for: child age, gender and national origin; maternal age, national origin, parity, education, income, marital status, depression symptoms and parenting stress

**Discussion**

In this study we sought to test the hypothesis that child executive function at preschool age is associated with bullying involvement in early elementary school, and examine whether this association is independent of child non-verbal IQ and ADHD problems. Our

results suggest that children with inhibition problems, observed by a parent at the age 4 years, are at risk of being a bully, victim or a bully-victim in the first grades of elementary school. Further, a higher risk of being a bully was associated with working memory problems. Conversely, children with higher IQ scores were less likely to be victims and bully-victims in early elementary school.

**Table 3** Child executive functioning and victimization in early elementary school (*n*=1,114)

Executive functioning	Risk of being a victim			
	Univariate model		Adjusted for covariates <sup>a</sup>	
	<i>OR</i> (95 % <i>CI</i> )	<i>p</i> -value	<i>OR</i> (95 % <i>CI</i> )	<i>p</i> -value
Domains of executive functioning (per <i>SD</i> )				
Inhibition problem score	1.15 (0.96–1.38)	0.14	1.21 (1.00–1.45)	0.05
Shifting problem score	0.98 (0.84–1.15)	0.84	0.99 (0.82–1.18)	0.89
Emotional control problem score	1.04 (0.87–1.23)	0.68	1.07 (0.89–1.27)	0.48
Working memory problem score	0.99 (0.80–1.23)	0.94	1.00 (0.78–1.27)	0.99
Planning/organization problem score	1.02 (0.82–1.26)	0.84	1.02 (0.83–1.27)	0.82
Global scores				
Global executive composite (per <i>SD</i> )	1.06 (0.89–1.26)	0.51	1.10 (0.90–1.35)	0.36
Child IQ score	0.98 (0.97–0.99)	0.003	0.99 (0.98–1.00)	0.04

Analyses were conducted in 1,114 of 1,377 children ('uninvolved' *n*= 920, 'victim' *n*=194), as children categorized as 'bully' (*n*=163) and 'bully-victim' (*n*=100) were not included in this analysis

Victimization is self-reported. Higher scores on BRIEF-P subscales denote more problems

<sup>a</sup> Adjusted for: child age, gender and national origin, internalizing problems; maternal age, national origin, parity, education, income, marital status, depression symptoms and parenting stress.

**Table 4** Child executive functioning and bullying-victimization in early elementary school ( $n=1,020$ )

Executive functioning	Risk of being a bully-victim			
	Univariate model		Adjusted for covariates <sup>a</sup>	
	OR (95 % CI)	<i>p</i> -value	OR (95 % CI)	<i>p</i> -value
Domains of executive functioning (per <i>SD</i> )				
Inhibition problem score	1.62 (1.22–2.15)	0.001	1.55 (1.10–2.17)	0.01
Shifting problem score	0.94 (0.53–1.65)	0.80	0.88 (0.49–1.58)	0.62
Emotional control problem score	1.20 (0.83–1.72)	0.32	1.21 (0.80–1.83)	0.35
Working memory problem score	1.32 (0.90–1.91)	0.14	1.18 (0.72–1.94)	0.47
Planning/organization problem score	1.31 (0.88–1.94)	0.17	1.17 (0.77–1.78)	0.43
Global scores				
Global executive composite (per <i>SD</i> )	1.46 (1.08–1.96)	0.01	1.34 (0.91–1.97)	0.13
Child IQ score	0.94 (0.93–0.96)	<0.001	0.95 (0.93–0.98)	<0.001

Analyses were conducted in 1,020 of 1,377 children, as children categorized as ‘bully’ ( $n=163$ ) and ‘victim’ ( $n=194$ ) were not included in this analysis. Bullying is peer-reported, victimization is self-reported. Peer nomination scores were based on ratings by multiple peers. Higher scores on BRIEF-P subscales denote more problems

<sup>a</sup> Adjusted for: child age, gender and national origin; maternal age, national origin, parity, education, income, marital status, depression symptoms and parenting stress

With regard to executive function, our most conspicuous finding was that inhibition problems predicted children’s bullying involvement as a bully, as a victim and as a bully-victim. The observed associations were not confounded by child and maternal socio-demographic and psychosocial covariates. Additional adjustment for IQ showed that the effect of inhibition is independent of non-verbal intelligence. Finally, the results hardly changed after additional adjustment for ADHD problems, except for the group of victims in which the effect estimate was no longer statistically significant.

A negative association between inhibition and aggressive behavior (mainly reactive) has been reported in earlier studies of young children (Ellis et al. 2009; Hughes et al. 2000; Raaijmakers et al. 2008). Bullies, bully-victims, and to some extent also victims, display reactive aggression (Camodeca et al. 2002; Salmivalli and Nieminen 2002). Our results suggest that bullying involvement, most likely in a form of reactive aggression, could be related to children’s poor inhibitory control. In other words, children’s involvement in bullying may be partly due to their impeded self-control. Consider a situation involving social conflict. A failure to inhibit behavioral responses or to delay immediate verbal or physical actions in order to think ahead and choose the most appropriate behavioral strategy, may explain why these children are more likely to have problems with their peers. Our results suggest that poor inhibition may increase children’s risk of bullying involvement. These findings are in line with the studies showing that inhibition problems may increase the likelihood of children’s externalizing and internalizing problems (Nigg et al. 1999) and aggression (Ellis et al. 2009; Raaijmakers et al. 2008).

In some of the previous studies of executive function, problematic behavioral outcomes were attributed to children’s ADHD symptoms. In particular, impulsivity and inhibition problems are typical characteristics of children with ADHD symptoms. ADHD symptoms have been associated with bullying and victimization in several studies (Holmberg and Hjern 2008; Kumpulainen et al. 2001; Shea and Wiener 2003; Timmermanis and Wiener 2011; Unnever and Cornell 2003; Wiener and Mak 2009). However, in our study we showed that the effect of inhibition problems in bullies and bully-victims was largely independent of the attention deficit/hyperactivity problems, as the observed associations attenuated only slightly after adjustment for ADHD problems. Similarly, Raaijmakers et al. (2008) reported an association between aggressive behavior of preschool children and their inhibition deficits irrespective of children’s attention problems.

Children with working memory problems had a higher risk of being a bully; although, this finding was only marginally significant. Children with working memory problems have more difficulties holding information in mind that is needed to undertake an action. Poor working memory function results in difficulties implementing a required action and in difficulties remembering rules (Gioia et al. 2003). This suggests that these children struggle with remembering or implementing an appropriate behavioral strategy. Children who struggle with adhering to the group norms and rules may engage more often in bullying. Also, based on the social information-processing model, difficulties in recognizing social cues relevant for peer interactions, or difficulties remembering appropriate social responses (Crick and Dodge 1994), can influence child’s

behavior during a peer conflict. The observed effect of working memory on bullying is consistent with several earlier research findings. For instance, in a small study of 11–15 year-olds (Coolidge et al. 2004), metacognitive dysfunctions, such as problems with reading, memory and concentration, were found to be correlated with bullying. Furthermore, previous studies in older children (Séguin et al. 1999) and in young adults (Séguin et al. 2004) reported a relation between poor working memory and physical aggression.

In earlier studies (Coolidge et al. 2004; Ellis et al. 2009), child planning ability was related to bullying and to reactive aggression. However, these studies used small samples and examined the association in somewhat older children. Furthermore, the associations in these studies were not adjusted for important confounders, such as maternal educational level. In our study, the association between planning/organization and bullying (continuous analyses, see supplementary Table 1) was confounded by child and maternal covariates. Our hypothesis with regard to the effect of planning/organization on peer aggression could thus not be confirmed. This emphasizes the importance of considering many potential confounders, such as for instance maternal educational level, when studying the association between child executive function and behavioral outcomes.

The finding that emotional control problem score was not associated with bullying involvement was almost counterintuitive. On the other hand, there is little prior evidence for such association in earlier studies of the effects of executive function on aggression. Children with emotional control problems are emotionally explosive, moody and they often demonstrate exaggerated emotional reactions (Gioia et al. 2003). However, bullying is not necessarily seen as an emotional outburst; instead it is thought to be an intended and repeated aggression towards peers (Olweus 1993). Emotional arousal or anger are not the essential prerequisites of bullying (Salmivalli and Nieminen 2002), which could be a possible explanation of why emotional control problems and bullying were not associated.

Our final goal was to examine whether there was an effect of IQ on the risk of bullying involvement. It is well established that intelligence is protective against antisocial behavior and delinquency (Kandel et al. 1988; Lynam et al. 1993; White et al. 1989). Also, previous research in young children showed that IQ is negatively associated with child aggression (Huesmann et al. 1987). Our findings suggest that children with higher non-verbal IQ are less likely to be involved in bullying as victims and as bully-victims. Huesmann et al. (1987) suggested that “the lower IQ children do not possess the cognitive skills necessary to learn the more complex nonaggressive social problem-solving skills”. Thus a child with weaker intellectual abilities may struggle with conceiving alternative, less aggressive strategies for obtaining his or her goals. It could be that bully-victims persistently use aggressive strategies for their goal achievement and they may

struggle with changing their behavior. Furthermore, Huesmann et al. (1987) noted that regardless of the effects of aggressive strategies, the aggressive behavior of a child is likely to persist if this child is not able to learn to construct or to remember an alternative behavioral strategy. Furthermore, it has been suggested that “lower IQ may make success at any endeavor more difficult for the child, resulting in increased frustration, lower self-esteem and stimulated aggression” (Huesmann et al. 1987). In this way, lower IQ may undermine children’s functioning making them more vulnerable to peer problems. In our study, a negative association was observed between non-verbal IQ and the risk of being a victim. This could mean that children with higher IQ are more skilled in either preventing peer victimization or in effective resolution of peer conflicts.

### Strengths, Limitations and Methodological Considerations

The aim of our study was to describe the association between child executive functioning and school bullying involvement using a population-based sample and controlling for several possible confounders. A large sample size, the use of parent report of executive functioning in combination with the peer/self-report of bullying involvement, along with an observational measure of child IQ, are the strengths of this study. Furthermore, we were able to describe the association between child executive functioning and bullying involvement for different bullying involvement roles (i.e., bullies, victims, and bully-victims vs. uninvolved).

Nevertheless, our study has some limitations which could be addressed in future studies. First, experimental and longitudinal data should be used to establish a temporal relation between executive functioning and bullying involvement. Executive function was assessed at the age of 4 years, when children are under a close supervision of an adult for most of the time, and at this age they are less likely to be involved in bullying. However, although children do not attend school at this age, the possibility of child’s involvement in bullying prior to the school entry cannot be ruled out. Future studies could address this by examining repeated measures of executive function and bullying. Second, the non-response analyses suggested some selection effects in the sample of the Generation R participants. This may have influenced the generalizability of our findings.

Two methodological considerations should be noted. First, we used a peer-nomination method to collect information about children’s bullying involvement. In our study victimization scores were calculated based on the number of the nominations children gave to their classmates when nominating their offenders. This is different from the questionnaire methods and from the methods requiring children nominate the victims in their class. We asked children to report about their own experience of victimization and to nominate their

aggressors. It was shown that at young age, self-reports of victimization are more accurate than the reports of peers about victimization of other children; whereas peer reports of aggression are more consistent than the self-reports of aggression (Österman et al. 1994). Based on the percentile cut-off used in previous studies, we categorized the bullying and victimization scores in order to define the groups of bullies, victims and bully-victims. However, this categorization is relative as children who are defined as “uninvolved” differ from those who are categorized as bullies, victims or bully-victims mainly in the severity of bullying or victimization.

Second, in our study we measured executive function using a behavioral rating scale. As discussed by Toplak et al. (2013), performance-based and rating measures of executive function assess different cognitive and behavioral aspects. The performance-based assessments measure children’s efficiency of cognitive abilities, while the rating assessments, such as the BRIEF-P, measure a child’s ability to pursuit and achieve a goal. Goal pursuing is an important aspect in the context of our study and thus we deemed this measure of executive function suitable for our study.

In sum, we examined an association between child executive functioning and the risk of bullying involvement in early elementary school using a population-based sample. Our results showed that children who have inhibition problems are more likely to be bullies, victims and bully-victims in the first grades of elementary school. Also, working memory problems appear to be associated with the risk of being a bully. Finally, children with higher non-verbal IQ are less likely to be victims and bully-victims. These findings suggest that peer interactions may be to some extent influenced by children’s executive function and non-verbal intelligence. Future studies should examine whether addressing executive function skills can improve the quality of peer interactions.

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