Title: Parental perceptions of aggressive behavior in preschoolers: inhibitory control moderates the association with negative emotionality

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Short title: Aggression, emotionality and inhibitory control

Abstract

Inhibitory control (IC) and negative emotionality (NE) are both linked to aggressive behavior, but their interplay has not yet been clarified. This study examines different NE x IC interaction models in relation to aggressive behavior in 855 preschoolers (aged 2-5 years) using parental questionnaires. Hierarchical regression analyses revealed that NE and IC predict aggression both directly and interactively. The highest aggression levels were reported in children with high NE and low IC. Interestingly, the protective effect of IC for aggressive behavior increases with rising levels of NE. Analyses focusing on physical aggression revealed a significant NE x IC interaction in boys aged 4/5 years only. These findings shed new light on potential compensatory mechanisms for aggressive behavior in developing children.

Keywords: Aggressive behavior, Inhibitory control, Negative emotionality, Preschool, Executive function

During the early preschool years, low to moderate levels of aggression are relatively common and are often thought of as a natural way of expressing negative emotions such as anger and frustration (Koot, Van den Oord, Verhulst, & Boomsma, 1997). Developmental trajectory studies have shown that the rate in which children engage in aggressive behavior increases and peaks during the second and third year of life and then gradually declines from the fourth year onwards (Alink et al., 2006; NICHD, 2004). The decline in aggression is thought to reflect increased brain maturation, as through gradual improvement of executive functions

children become increasingly able to regulate emotions and to control their behavior (Posner & Rothbart, 2000). Children who engage in high levels of aggression during the preschool period are at risk of engaging in a pattern of increasingly frequent and intense aggressiveness over childhood (NICHD, 2004) and a wide range of adaptational problems including academic failure, internalizing problems, and conflicts with family members, peers and teachers (Campbell et al., 2006).

As high levels of aggression pose major psychological and financial costs to society, families, and individuals (Tremblay et al., 1992), it is important to gain more insight in the factors involved in early aggressive behavior, to eventually be able to intervene adequately and timely. A propensity towards negative emotionality, which is the tendency to react to stressors emotionally, constitutes a significant risk for maladaptive development (Rothbart & Bates, 2006). High levels of NE and deficits in executive functioning have been linked to high levels of aggressive behavior (Calkins & Fox, 2002; Eisenberg et al., 2009; Muris & Ollendick, 2005). However, studies that have focused on both constructs and their interaction in relation to aggressive behavior in the early years are currently lacking.

Negative emotionality

NE is in part an early-developing, heritable and stable trait (Durbin, Hayden, Klein, & Olino, 2007), associated with neurophysiological factors such the neurotransmitter serotonin and the neuropeptide oxytocin (Montag, Fiebach, Kirsch, & Reuter, 2011). NE is considered to be the core dimension of the difficult temperament construct (Prior, 1992), and is generally defined as the child's tendency to react to stressors with high degrees of emotionality, including anger, irritability, fear or sadness (Rothbart & Bates, 2006). The construct of NE, is a defining feature of childhood conduct problems and externalizing problems (Calkins & Fox, 2002). However, many children do not develop aggressive behavior despite high levels of NE.

In fact, over the preschool years most children learn to modulate their emotions through deployment of self-regulatory skills, leading to a decrease in the use of aggressive behavior during development (Posner & Rothbart, 2007).

Self-regulation

Deficits in self-regulation are associated with early behavior problems (Eisenberg et al., 2009; Valiente et al., 2003). Self-regulation is a broad and multidimensional construct consisting of cognitive and behavioral processes that allow individuals to control physical, emotional, behavioral, and cognitive responses (Blair & Diamond, 2008). Although the capacity for self-regulation continues to develop throughout childhood until early adulthood (Murphy, Eisenberg, Fabes, Shepard, & Guthrie, 1999), the preschool years constitute a period in which individual differences in the ability to regulate attention and goal-directed behavior develop rapidly (Posner & Rothbart, 2000). This growth is marked by increased connectivity between neural systems and parallels significant maturation of the prefrontostratial circuitry (Carlson & Wang, 2007).

Traditionally, researchers have studied the development of self-regulation focusing on the concepts of, ‘effortful control’ and ‘executive functions’. Effortful control, a construct introduced by Rothbart and colleagues, is defined as “the efficiency of executive attention, including the ability to inhibit a dominant response and/or to activate a subdominant response, to plan, and to detect errors” (Rothbart & Bates, 2006, p. 129). Executive functions refer to a set of higher order cognitive processes, commonly defined as the ability to engage in deliberate goal-directed thought and action via inhibitory control (IC), attention shifting or cognitive flexibility and working memory (Garon, Bryson, & Smith, 2008). Although there are differences between effortful control and executive functions, the two constructs are

largely overlapping, with similar underlying neural systems (Nigg, 2006), and with IC as a central component (Zhou, Chen, & Main, 2012).

Inhibitory control

The capacity of IC, the ability to deliberately withhold or suppress a prepotent dominant response (Diamond, Carlson, & Beck, 2005) is one of the first executive functioning components to emerge in development and is seen as functionally different from other executive control components, such as working memory and cognitive flexibility (Garon et al., 2008). Deficits in IC appear to be consistently linked to aggression in school-aged children (Sterzer & Stadler, 2009), and preschoolers (Raaijmakers et al., 2008; Utendale & Hastings, 2011), although the findings in preschool children have not been replicated in other studies (e.g. Brocki, Nyberg, Thorell, & Bohlin, 2007).

In the present study, we specifically focused on the construct of IC, as opposed to broader constructs, such as effortful control or executive functioning, as previous research has shown that IC is of particular importance in understanding the development of aggressive behavior. For example, a self-report survey in nonclinical children showed that different aspects of effortful control are differentially related to specific behavioral problems (Muris, Meesters, & Blijlevens, 2007), such that deficits in IC but not attentional control were linked to externalizing problems. Furthermore, in a sample of four year old children with high levels of aggressive behavior, Raaijmakers and colleagues (2008) found that of the different executive functions only IC was significantly related to aggression.

Evidence for a moderation model

Although NE and IC have been independently linked to the development of aggressive behavior, the combination of high levels of NE and low levels of IC may place children at an

even higher risk for aggression (Calkins & Fox, 2002). In their literature review investigating the role of reactive and regulative temperament factors in the pathogenesis of child psychopathology, Muris and Ollendick (2005) put forward two models in which temperamental reactivity and regulative processes either have interactive or additive effects on the development of psychopathology. According to the interactive model, children high in NE may be prone to aggressive behavior, but may be relatively protected if they have adequate IC at the same time, whereas children with high NE and low IC may experience more difficulties in regulating NE and consequently are at greater risk for aggression. Adequate IC may therefore be particularly important for children high in NE.

Neuro-imaging studies of typically developing children and individuals with prefrontal cortex lesions provide support for this interactive model. These studies emphasize the importance of the role of the prefrontal cortex in the expression and regulation of different aspects of emotional reactivity (Beer, Heerey, Keltner, Scabini, & Knight, 2003; Perlman & Pelphrey, 2010), by attenuating activation in subcortical limbic regions, including the amygdala, which are essential to the processing of emotional information (Ochsner et al., 2004). Furthermore, developmental studies in children have reported significant relations between asymmetries of frontal electroencephalographic activations and temperament characteristics such as hostility, negative affect and reactivity to novelty (McManis, Kagan, Snidman, & Woodward, 2002).

Despite its theoretical plausibility, presently there are no studies in preschoolers that have actually examined the interplay between NE and IC in relation to aggressive behavior. Studies that did investigate the interaction, focused on global constructs of externalizing behavior or behavioral problems and general measures of effortful control using a variety of measures (e.g. Eisenberg et al., 2001; Muris et al., 2007; Valiente et al., 2003). Moreover, most of this research has been conducted in school-aged children and adolescents, and only a

few studies included younger children (Belsky, Friedman, & Hsieh, 2001; Gartstein, Putnam, & Rothbart, 2012; Lawson & Ruff, 2004; Olson, Sameroff, Kerr, Lopez, & Wellman, 2005). However, the outcomes of these studies in older children provide support for a model in which NE and (components of) effortful control interact in predicting externalizing problems; the findings in preschool children are rather inconclusive. Belsky et al. (2001) failed to find either direct or interaction effects of observed attentional persistence, a subcomponent of effortful control, and observed NE at 15 months on parental reports of behavior problems at age 3. Similar findings were reported by Lawson and Ruff (2004). However, after creating groups of children showing high and low levels of NE and attentiveness, they found that children with high maternal ratings of NE and low observed attentiveness in the first two years of life had higher levels of parent reported behavior problems at 3.5 years, which is supportive for the moderation of NE by IC. In a sample of 3 year olds, Olson et al. (2005) reported that effortful control abilities and parental perceptions of anger (a subcomponent of NE) were associated with parental reports of externalizing problems, but the interaction between anger and effortful control was not significant. Gartstein et al. (2012) examined the contributions of NE and effortful control to externalizing problems from infancy to preschool at 7 months, 25 months, and 4 years using parental reports. The authors reported a significant interaction effect indicating NE was more closely related to externalizing problems when effortful control was low, but this finding was significant only for the oldest age group.

Overall, the literature suggest that the moderating effect of (components of) effortful control on the relation between NE and aggressive behavior may not occur until children reach the late preschool or elementary school years. One explanation for the absence of an interaction effect in younger preschoolers may be the immaturity of the frontostriatal systems. Due to this immaturity, regulatory skills may not yet exist or be able to affect NE resulting in higher levels of externalizing problems. In fact, over the preschool period, normative

increases in IC go hand in hand with marked decreases in aggressive behavior and externalizing problems (Lemery, Essex, & Smider, 2002). This is supported by a recent study in which poorer IC predicted more aggressive behavior in older preschoolers and kindergarten-aged children, but not in younger children (Utendale & Hastings, 2011).

The present study

The present study focused on the role of NE and IC, and their interaction, in the development of aggressive behavior using parental report data in a large sample of preschoolers. The preschool period is an important period to evaluate the impact of this interaction on behavior, given children's rapidly improving regulatory skills. To this end, an important aim was to test whether the interplay between parental perceptions of NE and IC would evolve over the preschool period. To our knowledge, the present study is the first to examine the unique and interactive contributions of NE and IC in relation to aggressive behavior in this age group.

Based on the interactive model put forward by Muris and Ollendick (2005), it was hypothesized that parental perceptions of IC would modulate the relation between parentally reported NE and aggressive behavior, such that the negative impact of NE was either enhanced at low levels of IC, or reduced at high levels of IC. We further predicted that the protective effect of high levels of IC would be stronger for children with high levels of NE. Because regulatory skills develop rapidly in young children, we expected the interplay between report of NE and IC to be more pronounced in older compared to younger preschoolers. We also considered possible sex differences in relations between parental reports of NE, IC and aggressive behavior, as a large number of studies has shown that, in general, boys show higher levels of aggressive behavior than girls from an early age on (Hay, 2007).

We conducted analyses to test the moderation model for parental perceptions of physical aggression in particular. Physical aggression (e.g. hitting, kicking and fighting) emerges around the first year and has been shown to peak during the second and third year and to gradually decline in the fourth year (Alink et al., 2006; NICHD, 2004). Over the preschool period, overt physical aggression is gradually replaced by other expressions of aggressive behavior such as verbal and relational aggression. Higher rates of physical aggression have been found in boys (Alink et al., 2006), whereas girls showed more relational aggression (Ostrov & Keating, 2004). Based on these findings, we expected age and sex to have a stronger moderating effect on the interplay between reports of NE and IC for physical aggression than for aggressive behavior in its broader form.

METHOD

Participants

Participants in the present study were sampled to represent the general population of children aged between two and five years old in The Netherlands. Recruitment took place over the course of December 2010 until March 2012 through child day care centers (*N*=8), preschools (*N*=20) and elementary schools (*N*=32) in different urban and rural areas. Children with documented physical or mental disorders were excluded from participation.

The sample consisted of 855 children (455 boys and 400 girls) aged 2.01-5.99 years (*M*=4.19, *SD*=1.08) and their parents. Families were predominantly Caucasian (85%), 5% Turkish or Moroccan, 1% Surinam or Antillean, 6% mixed (Caucasian and other origin) and 3% of other origin. Children were primarily from intact families (90%). In most families (61%) at least one parent completed higher vocational education or a university degree, in 30% of the families at least one parent completed higher secondary school and in 6% of the

families at least one parent completed lower secondary school or lower vocational education (in 3% educational status was unknown or at least one parent completed primary school).

Procedures and measures

The primary caretaker (usually the mother) completed a variety of questionnaires concerning the child's emotionality and behavioral regulation. The questionnaires could be completed at home in paper and pencil style or digitally through a link that was sent by email.

Negative emotionality. To assess children's NE, the primary caretaker completed the Dutch version of the Very Short Form of Rothbart's temperament questionnaires: the Early Childhood Behavior Questionnaire (ECBQ; Putnam, Gartstein, & Rothbart, 2006) for 2 year olds and the Children's Behavior Questionnaire (CBQ; Putnam & Rothbart, 2006) for 3 to 5 year olds. The Very Short Forms of the ECBQ and CBQ contain three 12-item scales and were designed to assess the three broad dimensions of temperament (i.e. negative affectivity, surgency and effortful control), which have consistently emerged from scale-level factor analysis of the standard forms of the (E)CBQ. The ECBQ items can be rated on a 7-point Likert scale ranging from 1 (*never*) to 7 (*always*). The CBQ items are to be rated on a 7-point Likert scale ranging from 1 (*extremely untrue of your child*) to 7 (*extremely true of your child*). The CBQ Very Short Form demonstrated both satisfactory internal consistency and criterion validity and exhibited longitudinal stability and cross- informant agreement comparable to that of the standard CBQ (Putnam & Rothbart, 2006). For the present study the subscale Negative affectivity (discomfort, sadness, fear, anger-frustration, and soothability) was used as a measure of the child's NE. The 12 items were averaged into one overall score for NE (Cronbach's alpha = .60 and .73 for the ECBQ and CBQ respectively).

Inhibitory control. IC was measured with the Inhibit subscale of the Dutch translation of the Behavior Rating Inventory of Executive Function – Preschool version

(BRIEF-P; Gioia, Espy, & Isquith, 2005). The BRIEF-P is a 63-item rating scale that assesses children's daily executive functioning in a variety of contexts. The BRIEF-P items are organized into five clinical scales (Inhibit, Shift, Emotional Control, Working Memory, and Plan/Organize), three clinical indexes (Inhibitory Self-Control, Flexibility, and Emergent Metacognition), and a Global Executive Component (GEC). The primary caregiver rated how often their child exhibited various behaviors in the past six months on a 3 -point scale (1 = *never*, 2 = *sometimes*, and 3 = *often*). The BRIEF-P is reverse-scaled, indicating that lower scores represent higher levels of IC.

The Dutch translation of the BRIEF-P (Van der Heijden, Suurland, De Sonneville, & Swaab, 2013) showed sufficient to high internal consistency, test-retest reliability, inter-rater reliability, and construct validity. Furthermore, it showed adequate convergent discrimant, and predictive validity. Scores of the BRIEF-P Inhibit scale correlated significantly (r =-.342, p<.001, n=719), with the Effortful control dimension (measured with the [E]CBQ), indicating that higher levels of effortful control were associated with better IC. In a random subsample of four- and five year olds (N=57, M age = 5.08 years, SD = .58, range 4.05-5.99), a computerized GoNoGo task (Amsterdam Neuropsychological Tasks; De Sonneville, 1999) was administered. Subjects have to press a key if a go signal appears on the screen and refrain from responding if they see a no-go signal (see for a more detailed task description Slaats-Willemse, Swaab-Barneveld, de Sonneville, van der Meulen, & Buitelaar, 2003). Deficits in response inhibition are reflected by a higher percentage of false alarms; this variable was significantly associated with lower levels of BRIEF-P IC (Spearman rank correlation rho (47)= .29, p<.05). The Inhibit scale consists of 16 items measuring the child's ability of impulse control, or the ability of stopping/ modulating actions, responses, and behavior ('has trouble putting the brakes on his/her actions even after being asked' or 'is impulsive'). All

items (raw scores) are summed to create a composite index of IC (Cronbach's alpha in the present sample was .89).

Aggression. The primary caregiver completed the Dutch version of the Child Behavior Checklist 1 ½ -5 yr (Achenbach & Rescorla, 2000; Koot et al., 1997). The parent is asked to indicate whether their child displayed any of the 100 behavioral descriptions in the last two months on a 3- point scale (0 = *not true*, 1 = *somewhat true or sometimes true*, and 2 = *very true or often true*), with higher scores indicating higher levels of problem behavior. The instrument yields two broad-band factors (i.e. internalizing and externalizing behavior problems) and seven narrow band factors (i.e., emotionally reactive, anxious depressed, somatic complaints, withdrawn, sleep problems, attention problems and aggressive behavior). The narrow-band subscale Aggressive behavior (sum of 19 items, raw scores) was used for the analyses in the present study.

Additional analyses were conducted with physical aggression as outcome variable. To this end, a subscale for physical aggression was created, consisting of 6 items from the Aggressive behavior subscale that were also derived by the NICHD (2004) to measure overt physical aggression to people, animals and objects.

The reliability and validity of the CBCL have been confirmed in several studies (e.g. Koot et al., 1997). Internal consistency (Cronbach's alpha) in this sample was .88 for Aggressive behavior and .75 for Physical aggression.

Data analyses

All variables were examined for outliers and violations of specific assumptions applying to the statistical tests used. For each variable, observations with values that exceeded three standard deviations from the mean were recoded to the next highest value, within three standard deviations from the mean (0.9% of the total number of observations across NE, IC,

Aggressive behavior and Physical aggression). IC was log transformed because of its skewed distribution. Pearson correlations and *t*-tests were used to determine whether age, sex and educational level of the primary caregiver needed to be included in the subsequent analyses as covariates. Educational level showed a non-normal distribution and was therefore dichotomized into low (no or primary education and lower vocational training to intermediate vocational training) or high (higher vocational training and university degree or higher) educational level.

Subsequently, hierarchical linear regression analyses were conducted to examine the associations between NE and IC and the two aggression scales (i.e. Aggressive behavior and Physical aggression), and the potential moderation by IC of the NE and aggression relation. All variables were centered prior to analyses (Aiken & West, 1991). The control variables (e.g. age, sex and/or educational level), NE and IC were entered in Step 1, and all relevant two-way interactions were entered in Step 2. The three-way NE x IC x Age and NE x IC x Sex interaction terms were entered in Step 3 to test whether the interaction between NE and IC was moderated by age or sex. In order to test the presence of potential age or sex differences that did not appear in the three-way interactions, the hierarchical regression analyses were rerun for 2/3 and 4/5 year olds (without interaction terms for Age) and boys and girls separately (without interaction terms for Sex).

Significant interaction effects were further examined following procedures recommended by Aiken and West (1991) NE was regressed onto aggression at three different levels of IC (at 1.5 SD below the mean, at the mean, and at 1.5 SD above the mean). A score of 1.5 SD above the mean for IC represents the recommended cutoff score for abnormal elevation and potential clinical significance (Sherman & Brooks, 2010). In order to gain a better (visual) understanding of the NE x IC interaction, IC was also regressed at three different levels of NE (at 1 *SD* below the mean, at the mean, and at 1 *SD* above the mean).

Significant interactions involving sex were examined by regressing IC onto aggression separately for boys and girls.

All analyses were conducted using the Statistical Package for Social Sciences (SPSS for Windows, version 19.0, SPSS Inc, Chicago).

RESULTS

The descriptive statistics are presented in Table 1. Preliminary analyses (*t*-tests) revealed that boys, compared to girls, showed significantly more parent reported Aggressive behavior ($t(740)=5.31$, $p<.001$), Physical aggression ($t(668)=7.36$, $p<.001$) and lower IC ($t(806)=6.41$, $p<.001$). However, boys and girls did not differ on NE ($t(728)=-.26$, $p=.799$). Children of higher educated families, compared to children of lower educated families, showed significantly less Aggressive behavior ($t(739)=3.11$, $p<.001$), Physical aggression ($t(728)=-.26$, $p=.799$), NE ($t(632)=3.34$, $p<.001$) and higher IC ($t(803)=3.17$, $p<.01$).

NE and IC were significantly associated ($r=.303$, $p<.01$). Both NE and IC were significantly related to Aggressive behavior (respectively $r=.314$, $p<.001$ and $r=.694$, $p<.001$), and Physical aggression (respectively $r=.157$, $p=.01$ and $r=.496$, $p=.001$). Age was not associated with any of the variables except for NE ($r=.208$, $p<.01$). Because Age was significantly related to NE, and Sex and Educational level were significantly related to both the predictor and outcome variables, these variables were included as covariates in subsequent analyses.

Aggressive behavior

The results of the hierarchical regression analysis for Aggressive behavior are reported in Table 2. Significant effects were found for NE ($pr=.175$, $p<.001$) and IC ($pr=.636$, $p<.001$) . Children with higher levels of NE and lower levels of IC showed higher levels of

Aggressive behavior. There was also a significant negative effect for Age (pr=-.125, p<.01). Further, a significant interaction effect was found for NE and IC (pr=.111, p<.01). The three-way interactions between NE, IC and Age and between NE, IC and Sex were not significant. Additional regression analyses for 2/3 and 4/5 year olds and for boys and girls separately in order to test the consistency of the NE x IC interaction effect across age and sex yielded similar results.

The significant interaction between NE and IC was further examined by plotting the relation between NE and Aggressive behavior separately at three different levels of IC (at 1.5 *SD* above, at the mean and 1.5 *SD* below the mean, see Figure 1 left). The association between NE and Aggressive behavior was found to increase with lower levels of IC. At high levels of IC (at 1.5 *SD* below the mean), the association between NE and Aggressive behavior was non-significant (β=-.020, p=.680). This relation was significant at mean levels of IC (β=.106, p<.001), and became stronger at lower levels of IC (at 1.5 *SD* above the mean; β=.232, p<.001). The NE x IC interaction was also examined by plotting the relation between IC and Aggressive behavior separately at low, mean and high levels of NE (at respectively 1 *SD* below, at the mean and 1 *SD* above the mean). The association between IC and Aggressive behavior increased with higher levels of NE, but was significant at all three levels (standardized beta's for 1 *SD* below the mean, mean and 1 *SD* above the mean NE respectively β=.566, p<.001, β=.650, p<.001, and β=.735, p<.001). As illustrated in Figure 1 (right), the level of Aggressive behavior was similar for different levels of NE when IC was high, while the level of Aggressive behavior increased from low to high levels of NE when IC was low.

Physical aggression

The results of the hierarchical regression analysis with Physical aggression (see Table 2), yielded significant main effects for IC (*pr*=-.431, *p*<.001), Sex (*pr*=-.186, *p*<.001), Age (*pr*=-.082, *p*<.05) and Educational level (*pr*=.084, *p*<.05). There was also a significant two-way interaction between IC and Sex (*pr*=-.103, *p*<.01). Examination of this interaction effect (see Figure 2) showed that the association between IC and Physical aggression was stronger for boys (β=.558, *p*<.001) than for girls (β=.327, *p*<.001).The three-way interactions between NE, IC and Sex and between NE, IC and Age were not significant.

Additional regression analyses in 2/3 year olds, yielded main effects for IC (*pr*=.465, *p*<.001) and Sex (*pr*=-.150, *p*<.05). In 4/5 year olds, there was a significant interaction effect between NE and IC (*pr*=.101, *p*<.05) which was moderated by Sex (*pr*=-.097, *p*<.05). Further examination of the three-way interaction between NE, IC and Sex in 4/5 year olds by running separate hierarchical regression analyses for boys and girls, showed that for boys there was a significant effect for IC (*pr*=.447, *p*<.001) and an interaction effect between NE and IC (*pr*=.162, *p*<.05), whereas for girls there was only a main effect for IC (*pr*=.346, *p*<.001).

Plotting the NExIC interaction for 4/5 year old boys (see Figure 3 left) showed that the association between NE and Physical aggression was only significant at lower levels of IC (1.5 *SD* above the mean; β=.242, *p*<.01). At high (1.5 *SD* below the mean) and mean levels of IC, the association between NE and Aggressive behavior was non-significant. Although the association between IC and Physical aggression was significant for all levels of NE (see Figure 3 right), the strength of the association increased from low to high levels of NE (standardized beta's for 1 *SD* below the mean, mean and 1 *SD* above the mean respectively β=.317, *p*<.001, β=.446, *p*<.001, and β=.575, *p*<.001).

DISCUSSION

The aim of the present study was to test a model in which temperamental negative emotionality (NE) interacts with inhibitory control (IC) in predicting aggressive behavior (and physical aggression specifically) using valid parental questionnaires in a community sample of preschoolers. This model is based on a model proposed by Muris and Ollendick (2005) who suggested that the vulnerability to externalizing problems (and psychopathology in general) is determined by high levels of NE and low levels of regulation. The results of this study supported this model, indicating that parental reports of aggressive behavior was predicted by the interaction between NE and IC, such that the negative impact of high levels of NE was reduced by relatively good IC and enhanced by relatively poor IC. Our findings therefore demonstrate that parental perceptions of early emotional and cognitive functioning are linked and interact to predict aggressive behavior in the preschool period.

We first examined the unique relations between NE, IC and aggressive behavior. As expected, parental reports of NE and IC independently predicted aggressive behavior over and above the effects of demographic variables such as age, sex and educational level of the primary caregiver. These findings are in line with existing studies using parental reports and/or direct observations indicating significant contributions of high NE and low IC to the development of aggression (Calkins & Fox, 2002; Raaijmakers et al., 2008; Utendale & Hastings, 2011). We then examined the interaction between NE and IC in predicting aggressive behavior and found that, irrespective of age and sex, higher levels of parental reports of NE were associated with higher levels of aggressive behavior and that this relation became stronger as IC progressed to clinically significant levels (i.e. > 1.5 SD above the mean; Sherman & Brooks, 2010). The association between reports of NE and aggressive behavior was not significant when IC levels were adequate. As expected, children who were characterized by high levels of NE and low levels of IC were rated significantly higher on aggressive behavior compared to children who were characterized by either high NE or low

IC, or low NE and high IC. We further expected that the protective effect of better IC would be stronger for children with higher levels of NE. This expectation was confirmed after inspection of plot in which the relation between IC and aggressive behavior was plotted for different levels of NE. The supplementary effect of low levels of IC was larger when children displayed higher levels of NE, underscoring the importance of good regulatory skills in children with high levels of NE.

Previous studies revealed that (components of) effortful control do not become a moderator of the association between NE and behavioral problems until children reach late preschool or early elementary school age. Our study differs from these earlier studies in several ways, which may explain these contrasting findings. First, whereas our focus was on IC as a regulatory mechanism, Gartstein et al. (2012) examined effortful control (composed of attentional control and IC) in relation to externalizing problems, while Belsky et al. (2001) and Lawson and Ruff (2004) focused on early attention as a regulatory mechanism in relation to behavioral problems. Processes related to attentional control may regulate NE and aggressive behavioral tendencies to a lesser extent. This is in line with literature suggesting that a lack of attentional control is more strongly linked to internalizing problems, whereas poor IC is more clearly related to externalizing problems (Muris & Ollendick, 2005). Second, both Belsky et al. (2001) and Lawson and Ruff (2004) used a longitudinal design in which NE and early attention were measured during the early toddler years whereas behavioral problems were measured around age 3. As both constructs undergo development in early childhood, this may also be a source of variation in results. Third, methodological differences may account for the lack of consistency between our study and previous findings, as NE and/or regulational abilities have mostly been measured through direct observation (e.g. Belsky et al., 2001; Lawson & Ruff, 2004; Olson et al., 2005) instead of parental reports. However, Gartstein et

al. (2012) also relied exclusively on parental report data providing evidence against this argument.

Analyses specifically aimed at physical aggression showed results consistent with those for aggressive behavior in general, and indicated that IC moderated the relation between NE and physical aggression. Interestingly, this interaction effect was present for older boys (4-5 years) only. The presence of age and sex effects for physical aggression, and their absence in aggressive behavior in its broader form, may be explained by the fact that physical aggression peaks during the early preschool period (Alink et al., 2006; NICHD, 2004) and is gradually replaced by verbal and relational forms of aggression. In addition, girls are suggested to be more inclined to show relational aggression (Ostrov & Keating, 2004), whereas boys show higher levels of physical and verbal aggression (Alink et al., 2006; Ostrov & Keating, 2004). Because the CBCL Aggressive behavior scale measures aggression in its broadest form, age and sex effect may not appear. In line with previous studies, we found that sex moderated the association between IC and physical aggression in that this relation was stronger for boys than for girls. This result is consistent with the fact that girls are generally better than boys in self-regulation and inhibitory control, with differences becoming particularly apparent in the 2 - 5 year age range (Kochanska, Murray, & Harlan, 2000).

In the present study, we did not assess relational forms of aggression, therefore we were not able to differentiate between physical and relational forms of aggression. Murray-Close and Ostrov (2009) showed that the association between physical and relational aggression was low in late preschool age and that both forms of aggression were stable within children over the preschool period. Testing the moderation model for different forms of aggression could be an interesting direction for future studies. In fact, a recent study conducted among adolescents reported differential relations between overt physical and relational forms of aggression and temperamental reactivity and self-regulation (Dane &

Marini, 2014). A study conducted by Gower and Crick (2011) in two samples of preschoolers showed that physical and relational aggression were both associated with low baseline autonomic nervous system arousal but only in the context of low effortful control.

The outcomes of this study provide an extension of the research that has so far mainly been conducted in school-aged populations, and support a model in which emotionality and regulation interact in predicting behavioral problems (Eisenberg et al., 2001; Muris et al., 2007; Valiente et al., 2003). Interestingly, for reports of aggressive behavior in general we found that the moderation effect of IC was consistent across the whole age range indicating that in children as young as two years old developing IC capacities may already buffer against the negative effects of high levels of NE. Whereas simple forms of self-regulation such as the inhibition of touching an attractive toy on request of parents, already develop during the first year of life (Kochanska, Tjebkes, & Forman, 1998), more complex and sustained forms of self-regulation develop later during the preschool- and school period. As for the self-regulation of emotions, there is evidence for a similar developmental pattern: simple forms develop during the first two years of life, such as the use of self-soothing, while later on in the preschool period new and more complex use of objects and interactions emerge to regulate emotional state (Diener & Mangelsdorf, 1999). In line with that, our findings reveal that the interaction between self-regulation (inhibition) and emotional reactivity is similar for different preschool ages. However, despite the consistency over ages, there might still be a developmental change in how the self-regulating processes manifest themselves behaviorally.

Considering the relative contributions of NE and IC to aggressive behavior, our findings suggest that the protective effect of high IC (particularly in the presence of high NE) is stronger than the protective effect of low NE. It may be the case that regulatory strategies (already) play a more important role than temperamental factors at this young age. However, this finding may also be explained by the fact that in this study NE was measured as a broad

temperamental factor. In fact, subcomponents of NE have been differentially related to externalizing and internalizing problems (Rothbart & Bates, 2006), with anger/frustration making more substantial contributions to externalizing problems, whereas fear/sadness are more predictive of internalizing problems. Hence, the relation between NE and aggression may have been attenuated by the inclusion of a general measure of NE. Future studies should incorporate more fine-grained measures of NE in order to gain more insight in the specific temperamental characteristics that play a role in the development of aggression and how these interact with development of IC and other regulatory capacities.

Certain limitations regarding this study should be noted. The first issue concerns the possible confounding or overlap between the measures used in this study. Sanson, Prior and Kyios (1990) have argued that relations between temperament and behavior problems may be caused by item overlap. However, recent studies have shown that links between parental reports of temperament and behavior problems remain even after removing overlapping items (Lemery et al., 2002; Oldehinkel, Hartman, De Winter, Veenstra, & Ormel, 2004). Moreover, the interaction between IC and NE in predicting aggressive behavior in the present study argues against simple overlap.

Another limitation is that the independent and dependent measures were drawn exclusively from parental report which may have influenced the strength of the associations between our measures. Parental reports of child functioning include a subjective component reflecting biases associated with differences in parental personality, emotional status, relationship with the child, knowledge of child behavior and inconsistent interpretation of items (Kagan, 1994). There are also studies that have shown that parental perceptions of their child were differentiated in meaningful and consistent ways (Bates, 1990). Nonetheless, future studies should incorporate multiple methods and informants to measure temperament, executive functioning and behavioral problems. Both laboratory and field observations of

aggressive behavior by independent raters, as well as behavioral and physiological measures of temperamental reactivity and regulation would provide stronger evidence for the patterns observed in the current study. A third limitation is that the data are correlational and collected at a single time point. Future studies should include prospective, multiple time point assessments of emotionality, regulation and aggressive behavior to more fully understand the dynamic interplay between emotionality and regulation and the persistence of aggressive behavior across development. A final note concerns the generalizability of our results. Although the children in our sample showed the full range of aggressive behavior problems and their scores were in line with normative samples (Achenbach & Rescorla, 2000), only a small portion of children showed aggressive behavior in the extreme range, limiting generalizability to clinical samples.

In conclusion, this is the first study that demonstrates that parental perceptions of aggressive behavior in a large community sample of preschoolers are specifically associated with the interactive effects of IC and NE. Based on the outcomes of this study, we propose that inhibitory control mechanisms may already play a role in regulating negative emotions in children as young as two years old. Parental reports of low levels of IC, especially in combination with high levels of NE, characterize children with high (borderline to clinical) levels of aggressive behavior. Interestingly, we found moderating effects of age and sex for physical aggression that provide more insight in the specificity of the interaction effects of NE and IC for aggression in preschoolers. High levels of aggression at this age may be predictive for a persistent pattern of aggressive behavior over childhood (NICHD, 2004), and have been associated with numerous negative adaptational outcomes (Campbell et al., 2006). We want to emphasize that the capacity of a preschool child to deal with his or her (difficult) temperamentally determined emotionality is not only explained by his or her biologically

determined capacities: these capacities are and will be constantly influenced by the social environment (predominantly composed by his or her primary caregivers).

This study can have important implications for intervention programs for toddlers and preschoolers whose parents report high levels of (physical) aggression and appear to be at risk for continued externalizing behavior problems. Early interventions aimed at improving children's emotional and behavioral regulation skills through parental perceptions and behaviors may be promising. For instance, previous studies have demonstrated a significant effect of maternal support on the child's reactivity and self-regulation (Robinson & Acevedo, 2001). For children in the late preschool age whose parent report high levels of physical aggression, our findings suggest that interventions in boys should focus on strengthening inhibitory control. This might be particularly effective in boys with higher levels of NE, given our findings that there are direct effects of IC on physical aggression as well as an IC x NE interaction effect. In girls aged 4-5, the direct effect of IC on physical aggression was less strong and the interaction effect was not significant, which suggests that interventions focusing on strengthening inhibitory control would be less effective. Other treatment strategies, for example those focusing on improving prosocial behavior and empathy, and problem solving might be more effective for girls. Further studies incorporating a longitudinal and multi-method design are needed to replicate the findings of the present study and to provide insight in the interaction between emotionality and regulation in relation to the development of aggression over time.

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Tables

Table 1. *Descriptives.*

N= 713	*M*	*SD*	Min	Max
CBCL Aggressive behavior	8.56	5.84	0	26
CBCL Physical aggression	.85	1.35	0	6
(E)CBQ Negative Emotionality (NE)	3.08	.89	1.00	5.70
BRIEF-P Inhibitory Control (IC)	23.60	5.43	16	40
Age	4.25	1.06	2.02	5.99
Sex (% boys)	51.9%			
Educational level (% low)	43.8%			

Table 2. *Hierarchical regression analyses predicting aggressive behavior and physical aggression from NE and IC.*

Step	Predictor	*Adjusted* R^2	ΔR^2	ΔF	β	*t*
CBCL Aggressive behavior						
1	Age	.497	.501	141.92***	-.09	-3.36**
	Sex				-.05	-1.78†
	Educational level				-.02	-.89
	NE				.14	4.71***
	IC				.63	21.92***
2	NE x IC	.506	.012	3.55**	.08	-2.95**
	NE x Age				.04	1.47

	ICx Age				-.01	-.44
	NE x Sex				-.04	-1.30
	IC x Sex				-.03	-1.12
3	NE x IC x Age	.505	.000	.02	-.00	-.07
	NE x IC x Sex				-.00	-.17
CBCL Physical aggression						
1	Age	.279	.284	55.85***	-.07	-2.20*
	Sex				-.17	-5.03***
	Educational level				-.07	-2.24*
	NE				.03	.92
	IC				.44	12.69***
2	NE x IC	.290	.016	3.22**	.05	-2.95
	NE x Age				.02	.43
	ICx Age				-.04	-1.17
	NE x Sex				-.04	-1.02
	IC x Sex				-.09	-2.74**
3	NE x IC x Age	.292	.004	1.94	.03	.72
	NE x IC x Sex				-.06	-1.73†

†<.10, *p<.05, **p<.01, ***p<.001

Figures

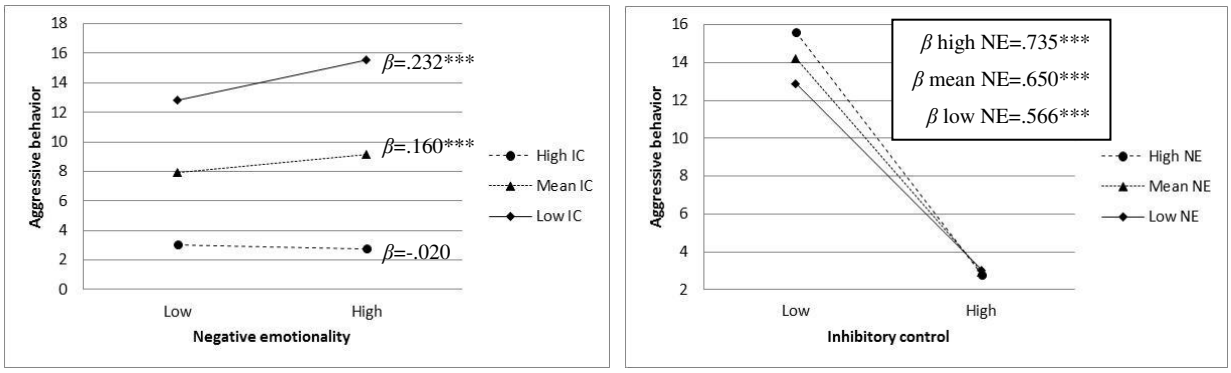

Figure 1. Interaction between NE and IC predicting Aggressive behavior plotted for different levels of IC (left) and NE (right). *Note:* Low IC= 1.5 *SD* above the mean, high IC= 1.5 *SD* below the mean, low NE= 1 *SD* below the mean and high NE= 1 *SD* above the mean. The asterisks (***) indicate p<.001.

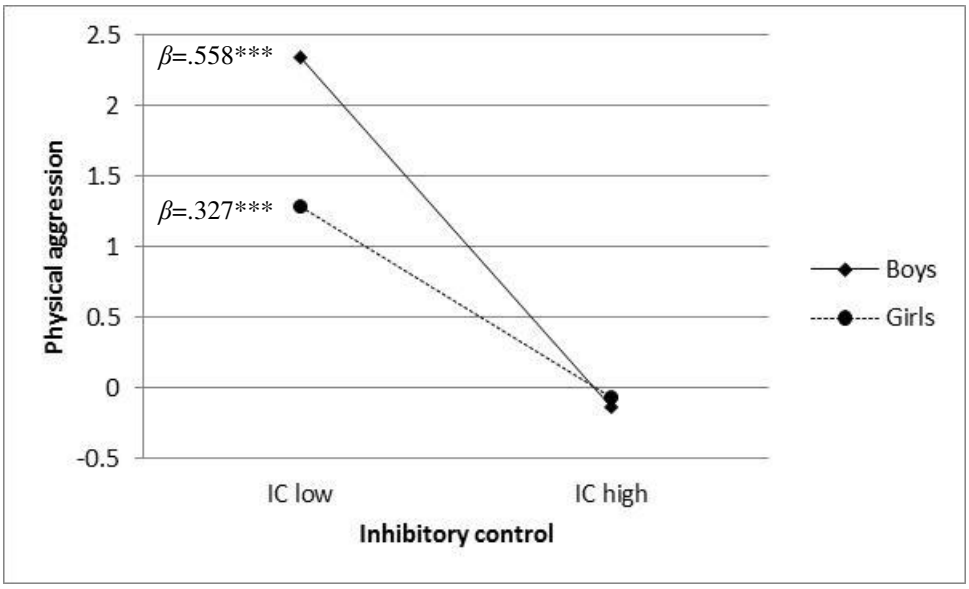

Figure 2. Interaction between IC and Sex predicting Physical aggression. *Note*: Low IC= 1.5 *SD* above the mean, high IC= 1.5 *SD* below the mean. The asterisks (***) indicate p<.001.

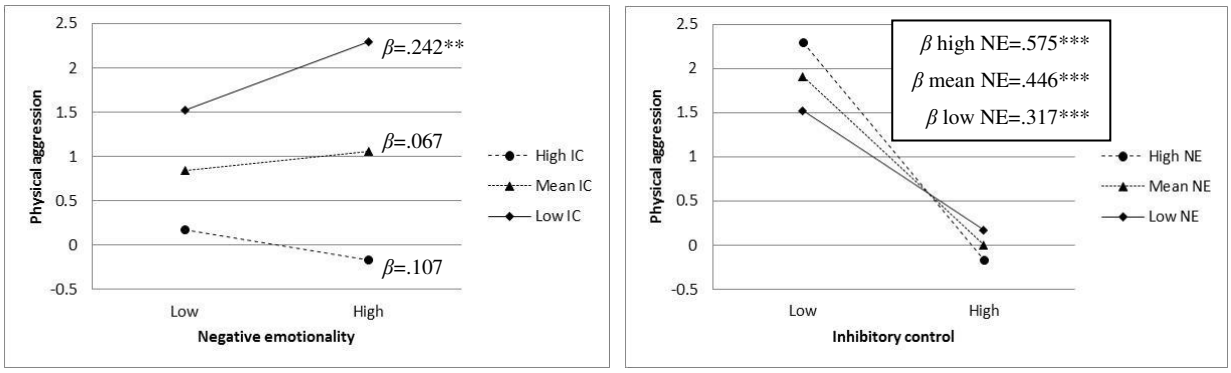

Figure 3. Interaction between NE and IC predicting Physical aggression for 4/5 year old boys plotted for different levels of IC (left) and NE (right). *Note*: Low IC= 1.5 *SD* above the mean, high IC= 1.5 *SD* below the mean, low NE= 1 *SD* below the mean and high NE= 1 *SD* above the mean. The asterisks (**) indicate $p<.01$ and (***) indicate $p<.001$.