Aggressive Behaviors in Young Siblings: Associations with Executive Functions and Maternal Characteristics

Catherine A. Spann & Jeffrey R. Gagne
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Abstract Aggressive behaviors in early childhood are associated with multiple undesirable outcomes, including juvenile delinquency, academic failure, and substance abuse. This investigation employed a family study design to examine child, mother and sibling predictors of early-emerging aggressive behaviors. These predictors included several indices of executive functioning within children, depression symptoms and education level of mothers, and inhibitory control (IC) of siblings. The sample consisted of 95 families (191 children; boys=100) with at least two, typically developing children between 30 and 66 months of age (M age=45.93 months, SD=12.40). Measures included laboratory-assessed working memory and IC, parent-reported aggressive behaviors, as well as self-reported maternal depression symptoms and education. Results revealed that children showed substantial sibling similarity in aggressive behaviors. Using multilevel regression analyses, low child IC and greater maternal depression symptoms were associated with increased child aggressive behaviors. Child working memory, maternal education, and sibling IC did not uniquely predict child aggressive behaviors. Moderation analyses revealed an interaction between maternal depression symptoms and maternal education, such that the effect of depression symptoms on child aggressive behaviors was particularly evident amongst highly educated mothers. The current analysis moved beyond a main effects model of maternal depression and extended previous findings on the importance of child IC to aggressive behaviors by using a multiple-child-per-family framework. A promising direction for future research includes assessing whether efforts to increase child IC are successful in reducing child aggressive behaviors.

Keywords Children · Aggressive behaviors · Externalizing problems · Executive function · Mothers · Depression

Early-emerging aggressive behaviors, including tendencies towards defiance, disobedience, physical violence, and angry moods, put children at risk for specific psychopathological conditions such as oppositional defiant disorder (ODD) and conduct disorder (CD; Campbell 1995; Lynam 1996). ODD and CD are associated with a host of negative long-term outcomes, such as academic failure, juvenile delinquency, substance abuse, antisocial behavior, unemployment, and mental health problems (Fergusson and Horwood 1998; Fergusson and Lynskey 1998). Given these adverse outcomes, understanding the development of aggressive tendencies is necessary to identify opportunities for prevention and intervention. With this goal in mind, the present investigation employed a family study design to identify predictors, both within the child and among family members, of early-developing aggressive behaviors.

Behavioral antecedents to aggressive acts emerge around 12 months of age with stable and coherent individual differences appearing in the 2nd year of life (Hay 2005). By the toddler years, some children are already showing explicit aggressive inclinations and it has been shown that some preschool children are demonstrating oppositional behavior and conduct problems on a clinical scale (Keenan and Wakschlag 2002). High levels of aggressive behaviors early in life hinder adjustment to preschool groups and the development of interpersonal relationships later in life. Understanding the early development of aggressive tendencies can help prevent the
strenthening of early individual differences into established aggressive dispositions.

Although there is considerable variability in the extent to which children exhibit aggressive tendencies, aggressive behavior typically decreases throughout the preschool and childhood years with the sharpest decline occurring between the ages of 2 and 7 (Miner and Clarke-Stewart 2008). This time period coincides with the rapid development of executive functioning (EF) skills needed to regulate behaviors and emotions. EFs are a family of control processes that are essential for thinking, concentrating, and planning and involve the core cognitive abilities of working memory and inhibitory control (IC; see Diamond 2013 for review). Working memory emerges toward the end of the 1st year of life and involves holding perceptually absent information in mind and mentally manipulating it (Baddeley and Hitch 1994). Working memory is vital for the functioning of IC—referred to as the ability to control one’s thoughts, attention, behaviors, and/or emotions in an effort to override a strong impulse or external temptation (Diamond 2013). To actively override an automatic response, one must have the ability to remember that a more appropriate response is necessary. Hence, children with poorly developed working memory typically do not perform well on measures of IC (Carlson et al. 2002).

EF can be characterized by the problem-solving framework (Zelazo et al. 1997) which views EF as a composition of distinct components that together contribute to goal-directed problem solving. An advantage of this approach is that it incorporates discrete EF processes into a unitary, coherent model. It has been argued that the problem-solving framework is a particularly useful model for understanding the development of aggressive tendencies (Séguin and Zelazo 2005), because embedded in the problem-solving framework is the idea that cognitive deficits in aggressive preschoolers are not necessarily global. This framework suggests that a child’s failure in a relatively cool (i.e., absence of emotions) EF task indicates their unlikelihood of changing perspective in an affective situation, whereas the child who demonstrates flexibility on a relatively cool task is more likely to change perspective when faced with an emotionally-charged situation.

Early EF deficits have been consistently linked to later developing externalizing problems (Brocki et al. 2010; Hughes and Ensor 2008; Riggs et al. 2003). In children 2.75 to 6 years of age, increases in EF predicted reductions in externalizing problems over 1 year (Utendale and Hastings 2011). The relationship between EF and aggressive behaviors exclusively has received considerably less attention with very few studies examining this relationship among preschool-aged children. Séguin and Zelazo (2005) emphasized the need for studying specific behavior problems like aggressive tendencies rather than broadband categories such as externalizing disorders. Additionally, only a handful of studies of preschoolers have attempted to examine EF by isolating various components and very few have examined EF this way in relation to aggressive behaviors. Moreover, the existing research has tended to examine group differences in EF between typically developing children and those labeled as aggressive (Raaijmakers et al. 2008; Riccio et al. 2011) discounting this relationship across the broad range of aggressive behaviors. Although there is evidence to suggest that EF is a predictor of aggressive behavior in preschool and early childhood (Raaijmakers et al. 2008; Utendale and Hastings 2011), additional research is clearly warranted.

Along with EF, gender plays a distinct role in the development of aggressive behaviors. Gender differences have been found in physical aggression in children as young as 17 months of age (Baillargeon et al. 2012). Conversely, several researchers contend that there are no gender differences in the rate of aggressive behaviors, just differences in the appearance of the aggressive behaviors themselves. Crick et al. (1997) argued that while boys may use physical aggression to obtain a goal, girls use relational aggression instead (e.g., excluding other children from a play activity), even in the preschool years. These covert forms of aggressive behavior may go unnoticed by parents and teachers, ultimately leading to an underreporting of aggressive behavior in young girls. Further, the relationship between gender and EF and their interactive effect on aggressive behavior remains largely unexplored. Considering that gender differences have been reported in EF (particularly IC; Carlson and Wang 2007) combined with the fact that EF has been shown to predict aggressive behavior, an interesting question emerges: Are EFs equally relevant to the development of aggressive behaviors for both genders? Since young girls may express covert aggressive behaviors that frequently go unnoticed by parents and adults, it could be the case that girls remain low on parent-reported aggressive behaviors regardless of their EF skills. On the other hand, EF may influence boys’ overt aggressive behaviors to a greater extent. Thus, EFs may indeed be more relevant to the development of aggressive behavior for boys than girls.

While characteristics within the child are critically important for the development of aggressive behaviors, family members are also influential. In particular, a child’s interaction with his or her mother is related to multiple aspects of later social and emotional development (Ainsworth 1979). When mothers experience depression symptoms, a negative mother-child relationship is likely to transpire, wherein children are on the receiving end of increased negativity and reduced maternal warmth (Turney 2012). The negative impact of maternal depression on child behavior problems has been demonstrated many times (Goodman et al. 2011; Hughes and Ensor 2009; Knox et al. 2011). In fact, even when accounting for genetic influences, maternal depression predicts child behavior problems (Casp i et al. 2004). Additionally, mothers with lower education have children who tend to show more social,
emotional, and behavior problems than children of mothers with higher education (NICHD Early Child Care Research Network 2004). Although evidence suggests a direct association between maternal education and aggressive behaviors (Nagin and Tremblay 2001), higher education may serve as a shield to the negative effects of maternal depression. Economic advantage, which is intricately linked to maternal education, has been found to buffer against the negative consequences of maternal depression on cognitive development (Peterson and Albers 2001). The interaction between maternal depression and maternal education has yet to be tested on child aggressive behaviors.

Siblings are also influential to child outcomes. Siblings play an essential role in each other’s adjustment and show similarity in numerous developmental trajectories. With respect to sibling similarity in EF, this research is in its nascent stage with few family studies employing a non-twin sibling design. Behavioral genetic studies of EF with twin samples are also fairly limited and have focused on participants ranging in age from middle childhood to aging populations. In general, EFs are significantly heritable in childhood (Polderman et al. 2006), adolescence through adulthood (Ando et al. 2001), and in older adults (Lee et al. 2012). Heritability estimates range from 0.27–0.63 indicating that environmental factors are also very relevant to the etiology of EFs.

Siblings show resemblance in a variety of related outcomes including delinquency and substance use (Rende et al. 2005; Snyder et al. 2005). Regarding aggressive behavior, siblings show a substantial amount of similarity in middle childhood and adolescence (Edelbrock et al. 1995) and even toddlerhood (Saudino et al. 2008). In studies controlling for parental influence, peer relationships, as well as genetic factors, sibling characteristics still account for significant amounts of variance in child outcomes (Kim et al. 2007; Rende et al. 2005; Snyder et al. 2005). Considering the significant amounts of unexplained variance, understanding the mechanisms by which siblings exert influence on each other’s aggressive behavior is necessary.

The Current Study

Using a family study design, the present investigation sought to identify both child- and family-level predictors of early-emerging aggressive behaviors. Our first goal was to replicate and extend findings of the relationship between EF and aggressive behavior using multiple siblings within the family. Specifically, we first hypothesized that higher child EF would predict lower child aggressive behavior. Second, we predicted that child gender would moderate the relationship between EF and aggressive behavior, such that boys would show a stronger negative relationship between EF and aggressive behavior than girls. Third, we expected maternal factors to predict child aggressive behavior, whereby lower depression symptoms and higher education would predict lower child aggressive behaviors. Fourth, we expected maternal depression symptoms and education to interact with one another to produce an effect on child aggressive behavior. Specifically, we expected higher maternal education to act as a buffer against the negative effects of maternal depression symptoms. Our last hypothesis predicted that siblings would influence each other’s aggressive behavior, with higher IC in one sibling being related to lower aggressive behavior in the other.

Method

Sampling Procedure

Recruitment began in late 2012 via flyers on campus, pediatricians’ offices, and day care centers. Families were also recruited through Internet and website postings. Based on recommendations by Kenny et al. (2006), we aimed to recruit a minimum of 80 families in order to detect a medium effect of 0.30 using an alpha of 0.05 and power of 0.78. The current study achieved this with 100 families recruited.

Mothers with at least two children between the ages of 30 and 66 months were eligible. Mothers were required to have Internet access via computer or mobile device to complete the online surveys. Eligible families were required to travel to the university as well as consent to video/audio taping and DNA collection. Only typically developing children were included, thus children with any developmental disorders (e.g., autism) were excluded. Two children were removed from the sample due to sensory processing disorder and one child was removed due to autism. Mothers disclosed this information on the CBCL when asked if the child had any illness or disability (either physical or mental).

Interested participants completed an online screening after which qualified participants were invited to complete a series of online surveys. Of the 126 families who completed the online surveys, 79.37 % participated in the laboratory visit. There were no differences in maternal age (p=0.40), paternal age (p=0.41), maternal education (p=0.76), paternal education (p=0.91), or family income (p=0.84) between those who participated in the lab visit and those who did not. However, those completing only the online surveys had children who were significantly younger (M=36.64 months, SD=13.66) than those who participated in the lab visit (M=45.93 months, SD=12.40), t(246)=4.70, p<0.001. This is most likely due to the fact that the children of survey-only participants were too young and, thus, ineligible for the lab visit. Although we attempted to enforce inclusion criteria via electronic communication as best we could, some mothers completed the online surveys for children who were not in the appropriate age range. Nevertheless, the ages of survey-only participants does...
not influence the present results. All procedures were reviewed and approved by the Institutional Review Board.

Participants

Of the 100 families who attended the laboratory visit, five were removed due to childhood disorders or failure to complete laboratory procedures. The current sample included 95 mothers with at least two typically developing children between the ages of 30 and 66 months. All participants completed online assessments and a laboratory visit. Of the 95 sibling groups, 54 were full sibling pairs, 10 were monozygotic twin pairs, 19 were same-sex dizygotic twin pairs, 11 were group of triplets. Many mothers’ groups were targeted and a number of these groups were mothers of multiples groups. This, along with the intentional age restriction led to a higher number of multiples (43 %) in the current sample. The present analyses included 191 children (boys=100) with a mean age of 45.93 months (SD=12.40). The average age of boys was 44.75 months (SD=11.74), while the average age of girls was 47.22 months (SD=13.02). The mean age of mothers was 34.13 years (SD=5.13) with an average of 15.58 years of education (SD=2.25), while the mean age of fathers was 36.97 years (SD=6.56) with an average of 15.09 years of education (SD=2.69). Ninety-one percent of respondents reported being married to the biological parent of the children. Regarding ethnicity, 93 % and 92 % of mothers and fathers, respectively, were not Hispanic or Latino. Families were mostly white (88 % of mothers; 87 % of fathers) with the majority earning an annual income over $70,000.

Measures

EF Child working memory was assessed with a multi-location search task called Spin the Pots (Hughes and Ensor 2005). This task involved a number of visually distinct boxes arranged on a Lazy Susan. The number of boxes used depended on the child’s age (8 boxes for 2.5–3.5; 10 boxes for 3.5–4.5; 12 boxes for 4.5–5.5). The child was asked to help the experimenter place stickers in the boxes. The experimenter told the child that there were not enough stickers to fill all of the boxes and two must remain empty. After the stickers were placed in all but two boxes, the experimenter closed all boxes and placed an opaque cloth over the Lazy Susan. Following this, the experimenter turned the Lazy Susan one time around. The experimenter removed the cloth and asked the child to pick a box that had a sticker in it. After making their selection, the experimenter placed the cloth back on the boxes and rotated the Lazy Susan again. This was repeated until all stickers were located or until the maximum number of spins was met (12 spins for 2.5–3.5; 16 spins for 3.5–4.5; 20 spins for 4.5–5.5). Performance scores were calculated by taking the proportion of stickers to spins making the possible range of scores 0 to 1. Higher scores reflected greater working memory. Although reliability has not been established, Lalonde and Holt (2014) administered this task twice to children two years of age and found that scores at test and retest were significantly related (r=0.59, p=0.002).

Child IC was measured using a modified Stroop task, in which the child needed to suppress an automatic response in order to give a correct response. Like Spin the Pots, this task was modified for different ages. Children 2.5–3.5 completed the Baby Stroop task (Hughes and Ensor 2005). This task involved showing the child a small cup called the baby cup and a regular-sized cup called the mommy cup. The experimenter asked the child to point to the baby cup and the mommy cup to ensure they understood which cup belonged to whom. The experimenter told the child that they would play an opposites game in which baby would use the mommy cup and mommy would use the baby cup. The experimenter told the child to say “mommy cup” when they saw the baby cup and vice versa. The experimenter showed each cup in a pseudorandom order, bringing one forward at a time for a total of 12 trials. No psychometric data are available for the Baby Stroop Task. Children 3.5 to 4.5 completed the Hand Game (Hughes 1998). This task involved the experimenter making a fist and pointing a finger while the child imitated the gestures. The experimenter told the child that they would play an opposites game in which the child must point a finger when the experimenter made a fist and vice versa. Again, this was repeated for 12 trials. Chasiotis et al. (2006) reported a Cronbach’s alpha of 0.88. Children 4.5 to 5.5 completed the Day-Night task (Gerstadt 1994). The experimenter showed the child a card with a sun telling him that this was the day card. Next, the experimenter showed the child a card with a moon and stars, telling him that this was the night card. Then, the experimenter informed the child that they would play an opposites game in which the child must say the word “night” when they saw the day card and say the word “day” when they saw the night card. This was repeated for 12 trials. For all three versions of the Stroop task, performance was calculated as the total number of correct trials. Possible scores ranged from 0 to 12 with higher scores reflecting greater IC. Internal reliability estimates range from 0.79 to 0.93 (Chasiotis et al. 2006; Rhoades et al. 2009; von Stauffenberg and Campbell 2007). Thorell and Wåhlin (2006) reported a test-retest reliability of 0.84.

Aggressive Behaviors The Child Behavior Checklist for Ages 1.5–5 (CBCL; Achenbach and Rescorla 2000) assessed aggressive behaviors. The CBCL is the most widely used standardized instrument for measuring child behavior and consists of a list of 99 items regarding the child’s behavioral and socio-emotional functioning. The instructions asked mothers to rate their child on behaviors concerning their
children within the past two months. The scale ranged from 0 (Not True), 1 (Somewhat or Sometimes True), to 2 (Very True or Often True). The completion of the CBCL form required parents to have English reading skills at or above a fifth-grade level. The aggressive behavior subscale was used to assess global aggressive acts. Cronbach’s alpha for the 19-item aggressive behavior subscale was 0.89.

**Maternal Depression Symptoms** The Center for Epidemiologic Studies Depression Scale (CES-D; Radloff 1977) is a self-report scale intended to assess depression symptoms occurring the week prior. This scale consisted of 20 items with response options ranging from 0 (rarely; less than 1 day), 1 (sometimes; 1–2 days), 2 (occasionally; 3–4 days), to 3 (most of the time; 5–7 days). Items were summed, making the possible range of scores zero to 60 with higher scores indicating the presence of greater symptoms. Cronbach’s alpha was 0.86.

**Maternal Education** Education of the mother was self-reported and measured in years of formal schooling completed (e.g., 12 for high school diploma, 16 for bachelor’s degree).

**Covariate**

**Verbal Ability** The Peabody Picture Vocabulary Test (4th ed.; PPVT-IV; Dunn and Dunn 2007) assessed child receptive vocabulary. Because verbal ability is associated with other child characteristics, such as age and cognitive development, including verbal ability as a covariate allowed for a purer measure of the relationship between the predictors of interest and child aggressive behaviors. To administer, the experimenter said a word from the standardized list and children pointed to one of four pictures that they thought correctly depicted the word. Testing proceeded until the child answered eight items incorrectly from a block of 12. Performance was based on the standardized score.

**Procedure**

Parents provided electronic consent before completing online questionnaires. Maternal depression symptoms and maternal education were self-reported using the online questionnaires after which parents were mailed a $25 gift card. Next, families came to the laboratory where they provided additional consent pertaining to procedures that day. Children provided assent during this time. Siblings were separated into two rooms, completing tasks separately with the experimenter. Experimenters included trained graduate and undergraduate students. While children participated in the behavioral tasks, mothers completed the CBCL for each child. The laboratory visit lasted approximately two hours and families received a $50 gift card upon completion.

**Results**

**Data Analysis**

Given the nested structure of the study design (e.g., siblings within families), multilevel linear regression was used as the primary means of data analyses. Multilevel regression models permit the appropriate modeling of the impact of individual level predictors on the dependent variable, yielding proper estimates of standard errors. The application of multilevel modeling to dyadic data required one major restriction, however, and that was to include only fixed effects with respect to the effect of individual predictors on the outcome (Kenny et al. 2006). In general multilevel models, the intercepts and slopes are allowed to vary from group to group, but with dyadic data, the slopes (i.e., the effect of X on Y for each dyad) must be constrained to be equal across all dyads. This is because the clusters do not have enough lower-level units to allow the slopes to vary from dyad to dyad. Importantly, the intercepts for the dyads can vary, and it is through this variation of the intercepts that the non-independence of each individual’s score was modeled (Kenny et al. 2006).

In order to investigate the predictors of aggressive behavior, hypotheses one through four were tested using a two-level random intercept model using restricted maximum likelihood (REML) estimation. Level 1 variables included child age, working memory, IC, verbal ability, and the interaction between gender and IC. Level 2 variables included maternal depression symptoms and maternal education as well as their interaction. Hierarchical linear modeling (HLM) software (Raudenbush et al. 2011) was used to test these hypotheses.

The last hypothesis regarding the effect of siblings was tested using an Actor-Partner Interdependence Model (APIM; Kenny 1996). The APIM model explicitly considers that in sibling research, outcomes reflect influences from both the particular individual and from his or her interpersonal system. This model assumes that when siblings interact, each child’s outcome is affected by both his or her own characteristics as well as his or her sibling’s characteristics (Kenny et al. 2006). Our hypothesis predicted that a sibling’s IC affects his or her own aggressive behavior (known as the actor effect), as well as his or her partner’s aggressive behavior (known as the partner effect). A conceptual model of this hypothesis is presented in Fig. 1. This hypothesis was estimated with multilevel analysis using HLM software.

**Data Screening**

Prior to formal hypothesis testing, data were screened for implausible and missing values using SPSS Missing Values Analysis. Two children did not complete any EF tasks or the verbal ability task and were removed from all analyses. Four variables were missing values: working memory (2.0 %),
Stroop task (11.2%), PPVT-IV (1.5%), and aggressive behaviors (2.0%). Using Little’s MCAR test, missing values were assumed to be missing completely at random, \( \chi^2(100)=108.62, p=0.26 \). Subsequently, missing values were imputed using the expectation-maximization (EM) algorithm. The imputed data were used for all analyses.

Variables were also screened to ensure the data met the assumptions of univariate and multivariate normality. The variables representing IC and maternal depression symptoms underwent square and square-root transformations, respectively, due to skewness. After transformations, all variables met the assumption of normality and the transformed variables were used in all subsequent analyses. The data met the assumptions of homoscedasticity, lack of univariate and multivariate outliers, and absence of multicollinearity among predictors. Additionally, the data met the multilevel assumption of homogeneity of level 1 variance for aggressive behavior.

Commonly in multilevel models, predictors are grand-mean centered. Commonly in multilevel models, predictors are group-centered. However, group centering with dyadic data removes all the variance due to dyad (Kenny et al. 2006). Thus, the zero point for all predictors was the grand mean of those variables.

**Correlations and Gender Differences**

A summary of means, standard deviations, and intercorrelations among all variables is presented in Table 1. Overall, aggressive behavior showed small relationships with child age, working memory, IC, verbal ability, and maternal depression symptoms and education. Notably, EF skills (working memory and IC) were unrelated. Moreover, child EF was unrelated to maternal depression symptoms and education, excluding small relationships between working memory and maternal characteristics. Lastly, maternal depression symptoms and maternal education were significantly correlated.

Gender differences were found only in IC, with girls \( M=97.04, SD=53.12 \) demonstrating significantly higher IC than boys \( M=78.01, SD=48.12 \), \( t(189)=-2.60, p=0.01, d=0.38 \). No gender differences were found in working memory, \( t(189)=0.69, p=0.49, d=-0.05 \), verbal ability, \( t(189)=0.34, p=0.74, d=-0.01 \), or aggressive behavior, \( t(189)=0.41, p=0.69, d=-0.05 \).

**Predictors of Aggressive Behaviors**

Prior to a test of the full model, the null model was tested, in which the only predictor of aggressive behavior was the family effect. This produced a baseline model fit of 98.92. The estimates of the family level variance (0.047) and residual variance (0.061) produced an intraclass correlation of 0.436 (0.047/0.108). Thus, 43.6% of the variance in child aggressive behavior was accounted for at the family level. This effect of family was significant, \( \chi^2(93)=237.857, p<0.001 \), indicating multilevel modeling was both appropriate and necessary.

Next, a hierarchical linear regression was conducted using REML estimation to assess the predictors of early childhood aggressive behavior. The full model took 11 iterations to converge and produced a model fit of 136.81, which was not a significant improvement over the null model. Table 2 presents the main effects of the child- and family-level predictors of aggressive behaviors.

- Greater IC was associated with lower aggressive behavior.
- No such relationship was found between working memory and aggressive behavior.
- Greater maternal depression symptoms were associated with greater child aggressive behavior.
- Maternal education did not have a significant main effect on child aggressive behavior.

**Moderation Effects**

Unexpectedly, child gender did not moderate the relationship between child IC and aggressive behavior, \( b=0.01, p=0.246 \). At the family level, however, maternal education moderated the effect of maternal depression symptoms on child
aggressive behavior, $b=0.37$, $p=0.013$ (Fig. 2). Specifically, aggressive behaviors significantly increased with greater maternal depression symptoms only at high levels (+1 $SD$), $b=2.21$, $p<0.001$, and mean levels, $b=1.37$, $p=0.008$, of education. The effect of maternal depression symptoms on child aggressive behavior was not significant at low levels ($−1$ $SD$) of education, $b=0.52$, $p=0.356$.

The Role of Siblings

The APIM model allowed for a test of the effect of one sibling’s IC on the other sibling’s aggressive behavior. Contrary to our hypothesis, while aggressive behavior could be predicted from the child’s own IC, aggressive behavior could not be predicted from their sibling’s IC, $b=0.01$, $p=0.436$.

Discussion

The primary aim of this study was to investigate predictors of aggressive behavior in very young siblings. We took a family study approach by examining how characteristics of children and their family members influence child aggressive behaviors, specifically focusing on EF and gender of children, depression symptoms and education level of mothers, and IC of siblings. Consistent with our hypothesis, EF—specifically IC—was significantly associated with child aggressive behavior supporting previous findings that IC is an important predictor of child aggressive behavior (Raaijmakers et al. 2008). However, working memory did not show a significant association with aggressive behavior, suggesting that IC component of EF is a stronger predictor of aggressive behavior than working memory. The importance of IC to the regulation of attention problems has been demonstrated repeatedly (Brocki et al. 2010; Riggs et al. 2003), consistent with Barkley’s (1997) theory that the predominant neurocognitive deficit in attention deficit hyperactivity disorder (ADHD) is a deficit in IC. The importance of IC to the regulation of aggressive behavior, however, has received substantially less consideration. By using multiple children within families, our findings demonstrate that, even after accounting for the influence of families, IC remains a significant predictor of child aggressive behavior.

Unexpectedly, child gender did not play a role in aggressive behavior. Not only was there a lack of gender differences in mean aggression levels, but also, contrary to our hypothesis, gender did not moderate the effect of IC on aggressive behavior. This finding indicates that boys and girls show the same relationship between IC and aggressive behaviors. However, consistent with other investigations of EF (Carlson and Wang 2007), we did find gender differences in IC. Considering that boys and girls typically differ in the type of aggression displayed—especially in later childhood and adulthood (Crick et al. 1997)—future investigations of IC and aggressive behavior should consider the role of gender.

Table 1: A summary of means, standard deviations, and intercorrelations among study variables ($n=191$ children; $n=95$ mothers)

<table>
<thead>
<tr>
<th>Variable</th>
<th>$M$ ($SD$)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Aggressive behavior</td>
<td>1.53 (0.33)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Working memory</td>
<td>0.65 (0.19)</td>
<td>−0.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. IC</td>
<td>86.54 (51.37)</td>
<td>−0.18*</td>
<td>−0.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Child age</td>
<td>45.93 (12.40)</td>
<td>−0.19**</td>
<td>0.17*</td>
<td>0.38**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Verbal ability</td>
<td>107.72 (14.00)</td>
<td>−0.12</td>
<td>0.17*</td>
<td>0.24**</td>
<td>0.30**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Maternal depression</td>
<td>2.79 (1.08)</td>
<td>0.25**</td>
<td>−0.11</td>
<td>0.05</td>
<td>0.01</td>
<td>−0.21**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Maternal education</td>
<td>15.56 (2.26)</td>
<td>−0.13</td>
<td>0.11</td>
<td>0.01</td>
<td>0.03</td>
<td>0.16*</td>
<td>−0.21**</td>
<td></td>
</tr>
</tbody>
</table>

IC was square transformed and maternal depression was square root transformed. Child age represents age in months

*p<0.05; **p<0.01

IC Inhibitory Control

Table 2: Main effects of aggressive behavior

<table>
<thead>
<tr>
<th>Fixed effect</th>
<th>$b$</th>
<th>SE</th>
<th>t-ratio</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>10.29</td>
<td>0.51</td>
<td>20.22</td>
<td>91</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Level 1 (Child-specific)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working memory</td>
<td>−0.82</td>
<td>2.00</td>
<td>−0.41</td>
<td>90</td>
<td>0.683</td>
</tr>
<tr>
<td>IC</td>
<td>−0.02</td>
<td>0.01</td>
<td>−2.47</td>
<td>90</td>
<td>0.015</td>
</tr>
<tr>
<td>Age</td>
<td>−0.08</td>
<td>0.03</td>
<td>−2.45</td>
<td>90</td>
<td>0.016</td>
</tr>
<tr>
<td>Gender</td>
<td>−0.06</td>
<td>0.43</td>
<td>−0.15</td>
<td>90</td>
<td>0.881</td>
</tr>
<tr>
<td>Verbal ability</td>
<td>0.01</td>
<td>0.04</td>
<td>0.23</td>
<td>90</td>
<td>0.818</td>
</tr>
<tr>
<td>Level 2 (Mother-specific)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td>1.41</td>
<td>0.51</td>
<td>2.75</td>
<td>91</td>
<td>0.007</td>
</tr>
<tr>
<td>Education</td>
<td>−0.11</td>
<td>0.21</td>
<td>−0.55</td>
<td>91</td>
<td>0.587</td>
</tr>
</tbody>
</table>

Gender coded -1 for males, 1 for females

IC Inhibitory Control
behavior should consider examining how this relationship may progress differently in boys and girls as they age.

Among characteristics of family members, maternal depression symptoms played the most prominent role, supporting previous findings of the negative impact that maternal depression has on child outcomes (Goodman et al. 2011; Knox, et al. 2011). Further, the effect of depression symptoms was moderated by maternal education, such that the effect of maternal depression on child aggressive behavior was only significant at high and mean levels of education. The direction of this interaction effect runs contrary to our hypothesis. In this sample, children of lower educated mothers (approximately 13.30 years of education) showed consistent levels of aggressive behavior as depression symptoms became higher. That is, lower educated mothers had children with higher aggressive behavior regardless of their depression symptoms. Conversely, children of higher educated mothers (approximately 17.82 years of education) showed greater aggressive behavior as depression symptoms became higher. Therefore, the negative impact of maternal depression symptoms on child aggressive behavior may be the most severe for mothers with higher education levels. This finding is in opposition to one previous study that found economic advantage to buffer against the negative effects of maternal depression symptoms (Petterson and Albers 2001). In this sample, maternal education correlated significantly with income ($r=0.36$), but the moderate relationship indicates education may not equate to economic advantage to the degree that other studies might find. Additionally, mothers in this sample who were considered to have low education still had some college education. The current finding should be interpreted with the consideration that the majority of participants in our sample could be considered affluent. Therefore, our finding of the vulnerability of children with highly educated mothers may be particularly true for families with higher income overall. This interaction effect should be examined among more diverse samples along with tests of other moderators of maternal depression symptoms.

Furthermore, contrary to our hypothesis, the IC of siblings did not directly influence child aggressive behavior. To our knowledge, this is the first attempt at assessing this relationship. One possibility for the lack of effect is that both full siblings and twin pairs were included in this analysis making it difficult to tease out the effects that older siblings had on younger siblings and vice versa. Ancillary analyses were conducted on full siblings and twin pairs separately, but lack of power likely prevented the detection of any effect had one existed. Future studies on the effects of sibling characteristics on child outcomes should consider including only twins or full siblings keeping in mind the additional time and resources for participant recruitment.

**Strengths and Limitations**

Our approach to child aggressive behavior is unique in the fact that we used a family study design. Not only were aspects within children considered, but characteristics of mothers and siblings were included as well. Krull (2007) noted the benefits of using multiple siblings within the family rather than a single-child-per-family approach. This design provides more power to detect effects and is ultimately less costly to the researcher when considering additional expenses for recruitment. Additionally, by including multiple siblings from the same family, it was possible to examine how much of the variance in aggressive behavior was due to differences between siblings within families and how much was attributable to differences in family means. In studies using just a single child per family, these two sources of variance are confounded. Moreover, we extended findings on the importance of maternal depression symptoms to child outcomes by moving beyond a main effects model and
exploring its interaction with another important maternal characteristic, education level.

Furthermore, the dyadic nature of the data allowed us to employ a statistical analysis not commonly seen in developmental research designs—the APIM model. Campbell and Kashy (2002) emphasized the fact that individuals involved in dyadic relationships often influence each other’s behaviors. Consequently, their outcomes are no longer independent of one another. The APIM model takes this interdependence into account while simultaneously considering the effects of both the primary individual and his or her partner. Although our specific hypothesis regarding the effect of sibling IC was not supported, researchers interested in sibling analyses should consider this valuable analytic tool.

While the study has several strengths, findings should be interpreted in light of limitations. First, our sample mainly consisted of white families from higher SES backgrounds. Therefore, results should be replicated with more diverse samples. Second, interactions between child- and family-level data were not tested, because dyadic data do not provide enough degrees of freedom to test cross-level interactions (Kenny et al. 2006). It is a possibility that the effect of a child’s IC on aggressive behavior is moderated by maternal characteristics or vice versa. Similarly, the effect of maternal depression symptoms on child aggressive behavior could be moderated by the gender of the child. A previous finding demonstrating a stronger effect of maternal depression on girls’ internalizing problems compared to boys (Goodman et al. 2011) supports the possibility of this interaction. In future family studies, researchers may consider including all children within the family in order to increase the lower level degrees of freedom, ultimately allowing for cross-level interactions. Certainly, the prohibitive financial and logistical costs of including all children in family analyses are a substantial burden to developmental researchers.

Next, paternal characteristics were not considered in the current study. Considering the demonstrated effects of paternal depression symptoms on child outcomes (Connell and Goodman 2002; Ramchandani et al. 2005), future studies should certainly consider collecting information from fathers if time and resources allow. Additionally, it should be noted that mothers in this sample rated their child’s aggressive behavior. Previous research has found that the effect of maternal depression on child outcomes was strongest when depressed mothers reported their child’s internalizing and externalizing behaviors relative to when teachers or observers did (Goodman et al. 2011). As Goodman et al. (2011) noted, this suggests that either depressed mothers are more sensitive to these behaviors or may be negatively biased in their perception. However, Fergusson et al. (1993) found that any over-reporting of behavior problems by depressed mothers likely represents a minor, albeit significant, contribution to any findings. Therefore, even if mothers in this sample who were experiencing more depression symptoms over-reported child aggressive behavior, it is doubtful that this had a large influence on the present results.

Lastly, our measure of working memory did not correlate with IC. Whereas a few previous studies have found a correlation between working memory and Stroop-related tasks (Carlson et al. 2002; Hughes and Ensor 2008), others have not (Archibald and Kerns 1999; Beck et al. 2011; Pasalich et al. 2010), suggesting the Stroop task may be a more pure IC measure compared to other assessments tapping into IC. The difficulty in examining EFs in early childhood (see Mulder et al. 2014 for discussion) has prevented a close psychometric examination of EF measures and the relatively nascent stage of EF research in early childhood makes it difficult to understand if this lack of correlation is indeed an issue. One possibility, however, for the current finding is the modification of the working memory task. For feasibility, the task was less demanding for younger children. Consequently, a young child with low working memory relative to an older child could have scored equally well on the task, which likely attenuated the relationship between working memory and IC. Future investigations of working memory across multiple age groups should not adjust for difficulty of the task if the desire is to look at the effects of working memory on outcomes across age.

Conclusions

This study demonstrated the importance of child IC in relation to child aggressive behavior, which is consistent with previous findings regarding the significance of IC to various outcomes. Even when measured at the age of 5, higher IC leads to a number of positive outcomes in adulthood, including physical and mental health, higher income, and fewer criminal acts at age 32 (Moffitt et al. 2011). Importantly, several activities have been shown to improve child IC, especially in younger children (for a review, see Diamond and Lee 2011 and Diamond 2013). A promising direction for future research includes assessing whether interventions aimed at increasing IC are successful in reducing negative outcomes. Early childhood is a period of malleability and it may be easier to modify behavior before it becomes engrained.

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Conflict of Interest The authors declare that they have no conflict of interest.
References


