Published in final edited form as:

J Abnorm Child Psychol. 2016 January ; 44(1): 31–42. doi:10.1007/s10802-015-0044-5.

Linking Executive Function and Peer Problems from Early Childhood through Middle Adolescence

Christopher J. Holmes, **Jungmeen Kim-Spoon**, and **Kirby Deater-Deckard**

Virginia Tech

Christopher J. Holmes: holmes11@vt.edu; Jungmeen Kim-Spoon: jungmeen@vt.edu; Kirby Deater-Deckard: kirbydd@vt.edu

Abstract

Peer interactions and executive function play central roles in the development of healthy children, as peer problems have been indicative of lower cognitive competencies such as self-regulatory behavior and poor executive function has been indicative of problem behaviors and social dysfunction. However, few studies have focused on the relation between peer interactions and executive function and the underlying mechanisms that may create this link. Using a national sample (n = 1,164, 48.6% female) from the Study of Early Child Care and Youth Development (SECCYD), we analyzed executive function and peer problems (including victimization and rejection) across three waves within each domain (executive function or peer problems), beginning in early childhood and ending in middle adolescence. Executive function was measured as a multi-method, multi-informant composite including reports from parents on the Children's Behavior Questionnaire and Child Behavior Checklist and child's performance on behavioral tasks including the Continuous Performance Task, Woodcock-Johnson, Tower of Hanoi, Operation Span Task, Stroop, and Tower of London. Peer problems were measured as a multi-informant composite including self, teacher, and after school caregiver reports on multiple peer-relationship scales. Using a cross-lagged design, our Structural Equation Modeling findings suggested that experiencing peer problems contributed to lower executive function later in childhood and better executive function reduced the likelihood of experiencing peer problems later in childhood and middle adolescence, although these relations weakened as a child moves into adolescence. The results highlight that peer relationships are involved in the development of strengths and deficits in executive function and vice versa.

Keywords

Executive function; peer problems; victimization; rejection; childhood; adolescence

Childhood and adolescence are periods of immense physical, emotional, and cognitive development. Identifying factors which may play a role in the full, healthy development of

Correspondence to: Christopher Holmes, M.S., Department of Psychology (MC 0436), Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 24061, U.S.A., holmes11@vt.edu.

Conflicts of interest: None

The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute of Child Health and Human Development or the National Institute of Health.

individuals during these periods, then, is crucial to explore. Executive function (EF) and peer relationships have been identified as playing central roles in healthy development; however, they have not been explored in tandem or through a developmentally comprehensive scope. As a result, the current study sought to elucidate longitudinal associations between EF and peer problems (PP) from early childhood through middle adolescence and explore potential sex differences in the reciprocal links.

Peer Relationships across Development

Peer relationships are vital in the healthy development of an individual from childhood through adolescence. However, the nature of these peer relationships changes considerably across these developmental periods due to changes in individuals' ability to interpret, respond to, and reason about peer interactions and behaviors according to developmental changes in physical, cognitive, and social skills (Fabes, Martin, & Hanish, 2009). Furthermore, socially acceptable behaviors differ across preschool, middle childhood, and adolescent years due to advances in expectations of sophistication in normative behavior (Bierman & Montminy, 1993). In the preschool years, children are exposed to larger numbers of peers in the preschool setting and the primary context of peer interactions is through play (Power, 2000) that advances in complexity from simply playing alone or alongside peers to more complex interactions with others (Fabes et al., 2009).

As children age into middle childhood, the complexity of peer relationships grows even further, requiring a wider and diverse social skill set (Fabes et al., 2009). Interactions are still considered play, but they become more organized, complex, and rule oriented while involving larger groups rather than just dyadic interactions. Successful peer interactions require more friendly and self-regulated actions, and aggressive and agnostic behaviors are predictive of poor peer interactions (Ladd, 2005). Furthermore, as children age into adolescence, a shift in peer interactions occurs as communication qualities become the central feature of peer interactions rather than play activities that are strictly tied to the classroom or school setting (Rubin, Bukowski, & Parker, 1998).

Associations of Peer Problems and Developmental Problems

Not all individuals experience positive peer interactions. PP are an age-invariant phenomenon found in childhood and adolescence (Kochenderfer-Ladd & Troop-Gordon, 2010). Some children and adolescents are subject to greater amounts of PP, which we characterized in this study as peer rejection and peer victimization experiences. Peer rejection and peer victimization have considerable overlap; but each is operationalized distinctively (e.g., Kochel, McConnell, & Ladd, 2007). Specifically, rejection "can be construed as encompassing peer behaviors that primarily serve to thwart another's overtures" including ignoring, dismissing, refusing or denying, whereas peer victimization can be construed as "actions that serve to inflict physical or psychological harm" including, aggression, abuse, and maltreatment (Ladd, 2009, p. 36). Whether they are overt or covert, PP are critical to a child's social-emotional adjustment and social status (Crick, 1997; Deater-Deckard, 2001; Parker, Rubin, Erath, Wojslawowicz, & Buskirk, 2006).

Children experiencing PP are at greater risk for a number of developmental issues as these negative interactions have considerable short and long term implications (Ladd, 2005). For example, a previous study has demonstrated that children with PP at age 4 experienced lower physical and cognitive competences at age 7 as measured by self-perception reports (Nelson, Rubin, & Fox, 2005). Similarly, children experiencing PP are prone to exhibit more internalizing or externalizing problems (for a review, see Deater-Deckard, 2001). Furthermore, PP have been shown to longitudinally contribute to problems including externalizing behaviors in a sample of children measured annually from kindergarten to third grade (Sturaro, van Lier, Cujipers, & Koot, 2011). PP for first and third graders have also been predictive of decreases in effortful control a year later (Iyer, Kochenderfer-Ladd, Eisenberg, & Thompson, 2010). However, this is an area still ripe for future research as potential underlying mechanisms of the effect of PP on development have gone largely unexplored to date. Furthermore, there is a need for longitudinal methods to explore how peer relations effect developmental changes across broader developmental periods (Hay, Caplan, & Nash, 2009) as existing research has focused primarily on childhood. Given the fundamental shift in the nature of peer interactions during the transition from childhood to adolescence, more research is needed to explore whether there may be developmental changes in the relation between PP and developmental outcomes.

Associations of Poor Executive Function and Peer Problems

Following Miyake and Friedman (2012), we define EF as the "general-purpose control mechanisms, often linked to the prefrontal cortex of the brain, that regulate the dynamics of human cognition and action" (p. 8). It includes three major sub-domains: inhibitory control, working memory, and attention/set shifting (Miyake & Friedman, 2012). Individual differences in EF are evident from early in development. Children show dramatic improvements in EF from 3 to 5 years of age, and stable individual differences emerge during this same developmental period (Jacques, Zelazo, Kirkham, & Semcesen, 1999; Zelazo, Frye, & Rapus, 1996). These individual differences can be measured reliably from early childhood into and through adolescence (Brocki & Bohlin, 2004). This variation reflects meaningful differences in children's and adolescents' cognitive regulation of thoughts, emotions and actions—variation that arises in association with other aspects of healthy and maladaptive functioning.

As a result, it is important to understand the connections between peer experiences and individual differences in EF from early childhood through adolescence. In the extant literature, there is evidence for the association between poor EF and PP. Balaraman (2003) found that poor inhibitory control, a particular facet of EF, at 3 years of age predicted more negative exchanges with peers with good inhibitory control at 4.5 years. Other studies showed that more cognitive and behavioral problems were associated with poorer EF among 4- to 6-year-olds, indicating that deficits in EF were related to more externalizing and internalizing problems and worse social understanding (Hughes, Dunn, & White, 1998; Hughes & Ensor, 2011) and, similarly, the increase in externalizing problems and decrease in social understanding may lead to higher PP as indicated by previous findings suggesting that externalizing problems longitudinally contribute to higher PP (e.g., Sturaro et al., 2011). Moreover, previous research has indicated that EF predicts later theory of mind which may be crucial factor in the development of PP. For example, Hughes and Ensor (2007a) demonstrated that higher EF at age 2 predicted higher theory of mind at age 3 and age 4. Moreover, similar research has implicated lower theory of mind with higher externalizing problem behaviors (Hughes & Ensor, 2007b) which may, in turn, lead to increased PP. Similarly, Fahie and Symons (2003) found that EF deficits were associated with more social problems and poorer theory of mind, both of which may in turn contribute to higher peer rejection and peer victimization among children (mean age = 6.5 years).

The Reciprocal Link between Peer Problems and Executive Function

Taken together, previous studies indicate that there may be reciprocal relations between PP and individual development, particularly EF. Hay, Payne, and Chadwick (2004) proposed a theoretical model exploring the underlying mechanisms that result in PP in childhood, and proposed reciprocal relations between individual development of EF, emotion regulation, and social understanding, and PP. Similarly, a recent review highlighted the bidirectional relations between adolescents' self-regulation and peer relationships such that better self-regulation contributed to better peer relations and vice-versa (Farley & Kim-Spoon, 2014). Also in parallel support of the proposed reciprocal relation between EF and PP, Stenseng and colleagues (2014) found that social exclusion of peers was linked with impaired self-regulation in the transition from preschool to elementary school and vice versa such that social exclusion was associated with impaired development of self-regulation 2 years later and poor self-regulation was associated with greater social exclusion 2 years later. However, this study is limited as it considered only two time points at age 4 and age 6 and their self-regulation measure assessed pathological deficiencies in regulation and temperamental regulation capacity, but did not consider cognitive regulation related specifically to EF.

Previous studies have shed light on the mechanisms that may explain why the reciprocal links exist between EF and PP. We first consider the link of PP contributing to EF. Prior theoretical work on childhood indicates that "play provides a critical forum for children's self-regulation" (Coplan & Arbeau, 2009, p. 150) as play tempers arousal associated with very high or very low levels of stimulation (Berlyne, 1960). In support of this, it has also been proposed that situations, such as play, provide for exploration and regulatory mastery over emotionally arousing experiences leading to greater ability to modify, monitor, and evaluate emotions for the appropriate situation in the future (Walden & Smith, 1997). Moreover, socio-dramatic pretend play has been empirically demonstrated as assisting in children's emotional understanding which was predictive of later self-regulation (e.g., Lindsey & Colwell, 2003; Youngblade & Dunn, 1995). Considering such prior findings, it may be concluded that popular children with less PP have more opportunities to develop important abilities including self-regulation (Coplan & Abreau, 2009).

In the same sense, there is also evidence that play specifically taps into EF skills, also providing opportunity to practice and develop them. For example, rough and tumble play has been shown to be an important context for developing inhibitory responses towards aggressive impulses in childhood (Peterson & Flanders, 2005). Furthermore, play has been implicated in the development of divergent thinking skills even while controlling for child IQ (Russ, Robins, & Christiano, 1999) as well as contributing to cognitive flexibility by forcing the child to try new things (Bateson, 2005). Interestingly, the mechanisms by which PP contribute to EF revolve around play activities in childhood, a feature already noted as being greatly diminished or even absent in adolescent interactions. As a result, it may be that adolescents' PP may contribute to further EF development less substantially than before, as they are not indicative of the amount of play opportunities that seem to be an underlying mechanism by which EF would be improved. To the authors' knowledge, however, there has been no systematic investigation examining the contribution of PP to EF development in adolescence.

Turning to the link of EF contributing to PP, there is also evidence to help inform the underlying mechanisms of this connection. A large volume of extant research suggests that children with higher effortful control, higher behavioral self-control, and lower task distractibility are generally well liked and thus less rejected or victimized (e.g., Gunnar, Sebanc, Tout, Donzella, & van Dulmen, 2003; Maszk, Eisenberg, & Guthrie, 1999; Walker, Berthelsen, & Irving, 2001). Similarly, effortful control has also been found as predictive of socially competent and less problematic peer behaviors (David & Murphy, 2007; Fabes et al., 1999). The better social adjustment outcomes shown among children with better EF may be, in part, explained by the fact that children with higher EF are more able to employ constructive methods to resolve conflict, such as inhibiting aggressive responses. For example, Eisenberg and colleagues (1994) demonstrated that preschoolers engaging in more constructive methods of conflict resolution were better liked by peers. Furthermore, in a sample of children and adolescents, better self-regulators were more socially competent, allowing for better quality peer relationships and thus less PP (McKown, Gumbiner, Russo, & Lipton, 2009). Taken together, it may be concluded that children and, to a lesser extent, adolescents with better EF experience less PP through a variety of mechanisms that serve to improve their ability to foster positive interactions with peers.

Sex Differences in Peer Problems and Executive Function

Prior evidence indicates that sex differences in peer interactions begin between 2 and 4 years of age in both structure and content (Rose & Smith, 2009). Regarding structure, gender segregation- or the preference to associate only with same gender peers instead of opposite gender peers-develops during this time and lasts through much of childhood (Hay et al., 2004). For example, girls have been shown more likely to share with other girls rather than with boys (Hay, Castle, Davies, Demetriou, & Stimson, 1999) and same sex disputes are more likely to be resolved by negotiation rather than coercion (Burford, Foley, Rollins, & Rosario, 1996). Females also prefer dyadic over group interactions (e.g., Hay et al., 2004), whereas males prefer to interact with friends simultaneously within the larger group (Rose & Smith, 2009). Regarding content, gender differences emerge in peer interactions in a variety of ways. For example, males are more physically aggressive than females (Archer, 2004). Furthermore, competition is more likely in males and competitive males, but not competitive females, are more liked by their peers (Marthur & Berndt, 2006; Sebanc, Pierce, Cheatham, & Gunnar, 2003). Males also engage in more rough and tumble play (e.g., Fabes, Martin, & Hanish, 2003), whereas females engage in more conversation, disclosure, and prosociality with peers (Rose & Smith, 2009). Considering this chasm between sexes in both structure and content of peer interactions, it seems likely differences will emerge in PP and how those problems are associated with EF development.

Sex differences, however, in EF are less clear and data have been inconsistent. For example, previous studies have found no main effects of sex on EF measures such as inhibition and working memory (e.g., Brocki & Bohlin, 2004; Welsh, Pennington, & Groisser, 1991). However, other studies have found lower levels of inhibitory control in males versus females (Berlin & Bohlin, 2002; Carlson & Moses, 2001). Considering these incompatible results, further exploration is needed to determine whether there are any potential sex differences in the link between EF and PP throughout childhood and adolescence.

Current Study

The current study seeks to expand upon the work on EF and PP. As the majority of early peer interactions occur in school, measures focus on social interactions with peers that occur in the school setting. We identify changes over time using three waves within each construct (EF or PP) from longitudinal data of children beginning in preschool period (4.5 years of age), when individual differences in EF begin emerging, at 6 years of age when children are in first grade, in school age period (at 9/10 years of age), and in adolescence (at 15 years of age). It should be noted that the first wave of each construct does not match the other (4.5 years for EF versus 6 years for PP) due to the unavailability of the constructs at each time point, resulting in an ‘uneven’ design for the first assessment of the cross lagged design. There were measures of EF at 4.5 years but not at 6 years, and measures of PP did not begin until the children were school aged, thus PP were available at 6 years but not at 4.5 years. Given the limited ability of children’s verbal and cognitive comprehension and production skills that threaten self-report validity in childhood (Fabes et al., 2009), measurement relies on parent, teacher, and after school caregiver report for questionnaire measures at 4.5, 6, and 9/10 years of age. However, considering the greater ability for adolescence to report on themselves and know more about their peer relationships than adults (Ladd, 2005), questionnaire measures at age 15 rely on self-reports. As a result, the current study may help address the great need for integration of cognitive and social development across developmental periods (Hay et al., 2009) while maximizing internal and predictive validity.

We had the following specific hypotheses. First, we hypothesized that children that experienced more PP, defined as peer victimization and rejection, would exhibit lower EF over time relative to their counterparts, concurrently and longitudinally into adolescence. Second, we hypothesized that children with lower EF would experience more PP compared to their counterparts, concurrently and longitudinally into adolescence. Finally, we explored whether sex differences emerged in the pattern of results given the sex differences in peer interactions and potential sex differences in EF development.

Method

Participants

The sample included 1,164 (566 female, 48.6%) participants from the SECCYD (http://www.nichd.nih.gov/research/supported/seccyd/datasets.cfm) dataset that participated at 4.5

years of age, 6 years of age, 9/10 years of age, or 15 years of age. However, not all participants completed all measures at every time point so full information maximum likelihood structural analyses were used. Self-report of race or ethnic group revealed that 75.3% were White, 11.8% were Black, 6.1% were Hispanic, 1.5% were Asian or Pacific Islander, 0.4% were American Indian, Eskimo, or Aleut, and 5% identified as other. Participants were recruited at 10 different sites across the United States. EF was measured at 4.5 years, 9/10 years, and 15 years, whereas PP were measured at 6 years, 9/10 years, and 15 years with differing starting points due to lack of relevant measures. Additional details about data collection procedures, participants, attrition, and measures are documented in the study's Manuals of Operation (http://www.nichd.nih.gov/research/supported/seccyd/Pages/overview.aspx#instruments). Procedures were approved by the relevant institutional review board for each of the 10 study sites and written informed consent was received from each family.

Measures

Both for EF and PP, composite scores were created among correlated indicators in order to maximize reliability (Rushton, Brainerd & Pressley, 1983). Moreover, this approach maximizes power and the predictive validity of constructs by reducing random error, while minimizing the study wide Type I error by vastly reducing the number of statistical tests conducted (e.g., Kim & Deater-Deckard, 2011). To further yield the most reliable composite scores with minimal method and informant bias, we incorporated indicators from multi-informant questionnaires and also task-based measures whenever possible. When both mother and father report were available, the scores were averaged to create a parent report; however, when only one parent provided data, it was used alone to create the parent score. Teacher and after school caregiver reports were included in the composites when available and these reports are noted below when applicable. As described in the project manual, after school caregivers included a variety of informants depending on the after school environment of the child, including paternal-care, after school program supervisors, or other means of supervision. All scales were coded in the same direction so that higher scores indicated higher EF or PP. Individual indicators were standardized, averaged, and standardized again to yield a composite z-score.

Executive Function—Our measure of EF included indicators reflecting inhibitory control, working memory, and attention. Composites were calculated separately at 4.5 years (pre-school), 9/10 years (third and fourth grade), and 15 years of age (high school) and bivariate correlations of individual measures can be found in Table 1. At 4.5 years, the composite was comprised of (1) average of mother and father report, $r = .33$, $p < .001$, on the attention focusing subscale of the Children's Behavior Questionnaire (Rothbart, Ahadi, & Hershey, 1994), (2) average of mother and father report, $r = .37$, $p < .001$, on the inhibitory control subscale of the Children's Behavior Questionnaire (Rothbart et al., 1994), (3) average of mother and father report, $r = .41$, $p < .001$, on the attention problems subscale of the Child Behavior Checklist (Achenbach, 1991), (4) number of correct responses on the Continuous Performance Task (Barkley, 1994) which measures sustained attention, and (5) standard score on the Woodcock-Johnson memory for sentences (Woodcock & Johnson, 1989) which measures the ability to remember simple words and repeat them back to the experimenter. A principal components analysis (PCA) found that 44.65% of the variance was explained and items loaded onto the component between .45 and .82.

At 9/10 years of age, EF was a composite variable comprised of (1) average of mother and father report, $r = .58$, $p < .001$, on the attention problems subscale of the Child Behavior Checklist (Achenbach, 1991) at age 9 and (2) at age 10, $r = .56$, $p < .001$, (3) number of correct responses on the Continuous Performance Task (Barkley, 1994) at age 10, (4) standard score on the Woodcock-Johnson memory for sentences (Woodcock & Johnson, 1989) at age 9, and (5) total planning efficiency score across tasks on the Tower of Hanoi (Anzai & Simon, 1979), which measures the child's planning and problem-solving skills by an organized series of moves to complete a goal, at age 9. A PCA found that 41.96% of the variance was explained and items loaded onto the component between .38 and .84.

At 15 years of age, EF was a composite variable comprised of (1) average of mother and father report, $r = .61$, $p < .001$, on the attention problems scale of the Children's Behavior Questionnaire (Rothbart et al., 1994), (2) total score on the Operation Span Task (Turner & Engle, 1989) which measures an individual's working memory, and (3) number of total moves on the Tower of London task (Berg & Byrd, 2002), similar to the Tower of Hanoi task used at 9/10 years of age. A PCA found that 40.44% of the variance was explained and items loaded onto the component between .43 and .76.

Peer Problems—PP focused on finding items that reflected peer rejection and peer victimization and these items tapped into the central constructs of peer victimization and peer rejection previously discussed. It was calculated separately at 6 years (first grade), 9/10 years (third or fourth grade), and 15 years of age (high school) and bivariate correlations of individual measures can be found in Table 2. As all indicators were obtained through the single method of questionnaires for PP, Cronbach's Alphas are reported for reliability. At 6 years, PP were a composite variable comprised of (1) teacher report and (2) after school caregiver report on the Popularity/Friends or Foes questionnaire (Ladd, 1983), (3) teacher report and (4) after school caregiver report on the Sociometric Status questionnaire (Cillessen, Terry, Coie, & Lochman, 1992). A PCA on the items in each measure found that 60.55% of the variance was explained and items loaded onto the component between .73 and .80. Cronbach's Alpha was .89.

PP at 9/10 years of age were a composite variable comprised of (1) teacher report and (2) after school caregiver report on the excluded by peers and peer victimization subscales of the Child Behavior with Peers questionnaire (Ladd & Profilet, 1996) at 9 years of age, (3) teacher report and (4) after school caregiver report on the excluded by peers and peer victimization subscales of the Child Behavior with Peers questionnaire (Ladd & Profilet, 1996) at 10 years of age. A PCA on the items in each measure found that 50.35% of the variance was explained and items loaded onto the component between .66 and .77. Cronbach's Alpha was .93.

PP at 15 years of age were a composite variable comprised of (1) self-report on the Loneliness and Social Dissatisfaction Questionnaire/Activities and Feelings questionnaire (Asher, Hymel, & Renshaw, 1984), (2) self-report on the Popularity/What My Peers Think

About Me questionnaire (Cillessen & Rose, 2005), (3) self-report on the University of Illinois Aggression Scale/Peer Relationships questionnaire (Espelage & Holt, 2001). A PCA on the items in each measure found that 55.62% of the variance was explained and items loaded onto the component between .70 and .82. Cronbach's Alpha was .87.

Results

The hypotheses were tested by Structural Equation Modeling (SEM) using the statistical software Mplus version 7.1 (Muthén & Muthén, 2010). Model fit indices were determined by Root Mean Square Error of Approximation (RMSEA) and Comparative Fit Index (CFI). RMSEA values of less than .05 were considered very good and values less than .08 were considered acceptable (Browne & Cudeck, 1993). CFI values greater than .95 were considered a very good fit and values greater than .90 were considered acceptable (Bentler, 1990).

Bivariate correlations of the zero-order are presented in Table 3 for EF at 4.5 years, 9/10 years, and 15 years and PP at 6 years, 9/10 years, and 15 years. To fit the model, we began by testing all possible paths in time sequence between EF and PP. Fit indices of this baseline model did not reach acceptable levels, $\chi^2 = 28.41$, $df = 2$, $p < .001$, RMSEA = .11, CFI = .98, thus we trimmed the longest cross-lagged paths from EF at 4.5 years to PP at 15 years and from PP at 6 years to EF at 15 years as the effects of the more temporally distant predictors were likely to be carried through more proximal cross-lagged paths. Model fit indices improved to acceptable ranges after these two paths were dropped, $\chi^2 = 29.69$, $df = 4$, $p < .001$, RMSEA = .07, CFI = .98, and a Wald Test revealed that model fit did not degrade significantly by setting these paths equal to zero, Wald Test = 1.28, $df = 2$, $p = .53$. Next, we tested whether removing the path from EF at 4.5 years to PP at 9/10 years so that the model consistently estimates only one cross-lagged path for each predictor, from t to t + 1. However, model fit, $\chi^2 = 66.25$, $df = 5$, $p < .001$, RMSEA = .10, CFI = .95, significantly degraded by setting this path to zero, Wald Test = 37.51, $df = 1$, $p < .001$. Therefore, we kept the path from EF at 4.5 years to PP at 9/10 years.

We next tested potential developmental differences in the cross-lagged effects. Specifically, we first tested developmental differences in the effects of PP on EF by examining whether there was a significant difference between PP at 6 years to EF at 9/10 years and PP at 9/10 years to EF at 15 years by imposing equality constraints between these two paths. A Wald Test revealed that model fit significantly degraded when these paths were constrained to be equal, Wald Test = 10.13, $df = 1$, $p < .01$, indicating that there was a significant difference between PP at 6 years to EF at 9/10 years and PP at 9/10 years and EF at 15 years, the nature of which is indicated below. Similarly, we tested whether there were significant developmental differences in the effects of EF on PP by comparing the three cross-lagged paths, including EF at 4.5 years to PP at 6 years, EF at 4.5 years to PP at 9/10 years, and EF at 9/10 years to PP at 15 years. When simultaneously constraining all three paths to be equal, results indicated model fit significantly degraded, Wald Test = 32.13, $df = 2$, $p < .001$, suggesting significant differences in the magnitude across the three paths. We then compared the paths to each other one at a time to determine which were significantly different. Results indicated that every path from EF to PP was significantly different from the other two paths from EF to PP, the nature of which is indicated below, Wald Test = 12.61, $df = 1$, $p < .001$ for equalizing between EF at 4.5 → PP at 6 and EF at 4.5 → PP at 9/10; Wald Test = 4.91, $df = 1$, $p = .03$ for equalizing between EF at 4.5 → PP at 9/10 and EF at 9/10 → PP at 15; and Wald Test = 32.16, $df = 1$, $p < .001$ for equalizing between EF at 4.5 → PP at 6 and EF at 9/10 → PP at 15.

A closer examination of the results of the final model, which may be seen in Figure 1, $\chi^2 = 29.69$, $df = 4$, $p < .001$, RMSEA = .07, CFI = .98, indicated that higher PP at 6 years was predictive of lower EF at 9/10 years, $b = -.14$, SE = .03, $p < .001$, but PP at 9/10 years was not a significant predictor of EF at 15 years, $b = .00$, SE = .03, $p = .92$. The earlier Wald Test indicated this path was indeed significantly lower than the path from PP at 6 years to EF at 9/10 years, suggesting significant diminishing effects of PP on EF as children age into adolescence. Turning to the effects of EF on PP, higher EF at 4.5 years was predictive of lower PP at 6 years, $b = -.36$, SE = .03, $p < .001$, and lower PP at 9/10 years, $b = -.20$, SE = .03, $p < .001$. Higher EF at 9/10 years significantly predicted PP at 15 years, $b = -.09$, SE = .04, $p = .01$. The effect sizes were significantly lower at each consecutive time point as noted by the earlier Wald Test, indicating the effects of EF on PP were significantly decreasing over time from childhood to adolescence. Additionally, a significant concurrent covariance was observed between EF and PP at 9/10 years, $r = -.21$, SE = .03 $p < .001$, but not at 15 years, $r = .00$, SE = .03, $p = .94$. Both PP and EF had significant autoregressive paths, $b = .35$, SE = .03, $p < .001$ for PP at 6 → PP at 9/10; $b = .22$, SE = .04, $p < .001$ for PP at 9/10 → PP at 15; $b = .57$, SE = .03, $p < .001$ for EF at 4.5 → EF at 9/10; $b = .57$, SE = .03, $p < .001$ for EF at 9/10 → EF at 15.

Next, sex differences were explored through a two group SEM comparing males and females. We began by predicting the final model in both groups simultaneously and model fit was acceptable, $\chi^2 = 34.13$, $df = 8$, $p < .001$, RMSEA = .08, CFI = .98. Next, we constrained the cross-lagged paths from PP to EF to be equal across groups and the model fit did not degrade significantly, Wald Test = 2.90, $df = 2$, $p = .23$, indicating that PP did not contribute differently to EF development in females versus males. In the following model, we added equality constraints on the cross-lagged paths from EF to PP across groups and model fit did not degrade significantly, Wald Test = 1.47, $df = 3$, $p = .69$, indicating there were also no group differences with respect to the path estimates from EF to PP. Therefore, it was concluded that there existed significant developmental changes in the reciprocal relations between EF and PP (Figure 1) but no significant sex differences.

Discussion

Although the importance of EF has been well-established and the contribution of social development to EF is beginning to be explored, little work has focused on the potential reciprocal relationships between EF and PP. Moreover, the few available studies considering the topic have been limited in the sample sizes, the scope of measures, informants, and number of longitudinal assessments. Therefore, we utilized a large, national sample which provided rich data across multiple time points, informants, and measures, allowing for maximization of statistical power, construct reliability, and predictive validity. The current study involved the testing of a cross-lagged model of EF and PP to better understand the associations between these critical factors in development. As a result, the present findings provide important contributions to the understanding of EF development as it is dynamically associated with peer relationship experiences from early childhood to middle adolescence. Finally, we sought to explore potential sex differences in these reciprocal relations, given the well documented sex differences in peer victimization and rejection (e.g., Rose & Smith, 2009), but mixed results for sex differences in EF development (e.g., Brocki & Bohlin, 2004).

Our first hypothesis, that children who experience more PP will exhibit lower EF over time (concurrently and longitudinally into adolescence) relative to their counterparts, was partially supported. There was a significant decline in effect size between the two time periods, indicating that higher PP were related to lower EF during childhood, but not in adolescence. The findings provide support for the theory that play activities in childhood relationships may contribute to the development of EF in childhood, and the lack of play in adolescence may partially explain the weakened effect from PP at 9/10 to EF at 15 years. That is, rejected or victimized children that do not have as much opportunity to play with peers in childhood will not have as much opportunity to practice and further develop EF skills (Coplan & Abreau, 2009), and the relative lack of play in adolescence may explain why the association of PP to EF is weakened in adolescence. Consistent with this finding, prior research has shown that several aspects of EF domains including attention control and cognitive flexibility are relatively mature by 12 years of age (Anderson, 2002), although neural circuitry underlying EF system continues to develop through the second decade of life (Johnson, Blum, & Giedd, 2009). Therefore, our findings suggest that the developmental trajectory of EF may be more sensitive to the impact of social interactions during childhood compared to adolescence.

Our second hypothesis, that children with lower EF will experience more PP compared to their counterparts, was supported. The current data indicated that lower EF was significantly associated with higher PP in the paths from 4.5 years to 6 years, 4.5 years to 9/10 years, and 9/10 years to 15 years. These findings are consistent with the theory that EF skills are essential for developing positive peer relationships (Hay et al., 2004). This theory has been supported in empirical studies that examined the association between EF and general social problems and social-emotional understanding in childhood (e.g., Balaraman, 2003; Fahie & Symons, 2003; Hughes et al., 1998). However, to our knowledge, the current study provides the first direct evidence that the association from EF to PP extends into adolescence.

It is worth noting, however, that the statistical predictive path from EF to PP significantly decreased at each consecutive cross-lagged estimate from childhood into adolescence. Such a finding indicates that, although still present later in childhood and into adolescence, EF becomes less critical to predicting variance in PP as children move into adolescence. As such, prior findings indicating that children with higher EF are more socially competent and are constructive problem resolvers with fewer PP (e.g., David & Murphy, 2007; Gunnar et al., 2003), may need to be considered over a broader developmental range. The field has not yet determined why these characteristics stemming from stronger EF may be less critical to peer relationship dynamics and functioning in adolescence, compared to childhood.

One possible explanation for this developmental trend is that as children age into adolescence, communication qualities become a central feature in peer interactions rather than play activities tied to the classroom or school setting (Rubin et al., 1998). Therefore, it may be that EF skills such as inhibitory control and working memory gradually become less important to the communication skills required in adolescent relationships, compared to other aspects of self-regulation—such as self-control of positive and negative affect—that may be even more characteristic of good versus poor quality peer relationships among teenagers. For example, college students with stronger emotion self-regulation skills receive more positive nominations from peers as well as a larger number of reciprocal friendship nominations, compared to those who are poor at emotion regulation (Lopes, Salovey, Côté, & Beers, 2005), suggesting the importance of emotion self-regulation in adolescent peer relationships. Alternatively, the diminished strength of the relation may be explained by the higher value other adolescents place on risky and impulsive behavior resulting from lower EF in adolescence. Previous literature has demonstrated that the developmental imbalance between adolescents' stronger reward system relative to their weaker control system may lead to higher vulnerability to risk taking behavior (for a review, see Albert, Chein, & Steinberg, 2013). Therefore, at least for some adolescents with low EF, their risk-taking behaviors may lead to positive reputations with peers and ultimately be associated with lower PP.

Additionally, we explored potential sex differences in the reciprocal relations between EF and PP and found no significant group differences in the magnitude of the reciprocal relations between males and females. This finding indicates that, although males and female peer relationships differ in structure and content (e.g., Rose & Smith, 2009), the way through which PP interface with EF may not significantly differ.

Limitations and Conclusions

Findings of this study need to be considered in view of the following limitations. First, the lack of peer nominations is a sizable weakness. Previous studies have indicated moderate to large correlations between self report and peer nominations for victimization, bullying and aggression among children (e.g., Bouman et al., 2012; Henry, 2006). Unfortunately, the SECCYD study did not include peer nomination because the participants were geographically distributed across many schools. Replication of the current findings using peer nominations would be beneficial as peer reports may help to elucidate more about the nature of self and adult reports of PP and subsequently their relation with EF. Second, the use of different items and tasks from various informants across the time points, due to changes in measures used during collection, required standardization of EF and PP scores to create a meaningful and interpretable composite z-score. As a result, mean levels differences across the time points could not be examined. The informants for PP switched from caregiver/teacher to self between childhood and adolescence as a result of available measures. However, as noted in the introduction, it has been suggested that individuals are better suited to report on their peer relationships in adolescence than are adult informants, whereas the reverse is true during childhood (Fabes et al., 2009; Ladd, 2005). Additionally, the lack of measures reporting EF and PP in late childhood required data from age 9 and 10 to be combined in order to create a reliable composite score, and there was a discrepancy in the assessment times between EF and PP, resulting in an 'uneven' design for the cross-lagged modeling. Finally, it should be noted that some of the associations found were relatively small, albeit statistically significant, seemingly reflecting the long intervals between our assessments (spanning 3 to 6 years). It has been suggested that statistical significance (e.g., effect size) does not indicate clinical meaningfulness and even small effect sizes are important if they have clear implications for significant theoretical and practical issues (Abelson, 1995). Regardless, the results must be interpreted with consideration that although EF and PP may reciprocally contribute to each other in significant and unique ways, there exist many risk and protective factors that determine EF and PP development.

Despite these methodological limitations, this investigation provides findings that contribute to filling the gaps in the present literature regarding the development of EF and the role of peers by offering the first evidence for reciprocal associations between EF and PP during early childhood and middle childhood. However, these reciprocal relations diminish as children age into adolescence. That is, higher PP appears to contribute to lower EF in childhood and higher EF appears to contribute to lower PP in childhood—but less so in adolescence. Moreover, these findings are not qualified by sex differences as no significant differences emerged in the reciprocal relations between females versus males. Taken together, the current findings highlight that individual differences in EF are important contributing factors in peer relationship quality, especially negative peer experiences, and difficult peer experiences are also involved in the development of EF—especially in childhood. The implications of such findings include the need for early and targeted preventive intervention efforts for children including low EF or high PP through cognitive-control and working memory training (e.g., Berkman, Graham, & Fisher, 2012) as well as strengthening social relationship skills and coping strategies (e.g., Bierman et al., 2008; Domitrovich, Cortes, & Greenberg, 2007).

Acknowledgments

We thank the study participants and research staff. This work was supported by a grant awarded to Dr. Jungmeen Kim-Spoon from the National Institute of Drug Abuse (DA036017). The Study of Early Child Care and Youth Development was conducted by the NICHD Early Child Care Research Network, and was supported by NICHD through a cooperative agreement that calls for scientific collaboration between the grantees and the NICHD staff.

References

Abelson, RP. Statistics as principled argument. Hillsdale, NJ: Erlbaum; 1995.

Achenbach, TM. Manual for the Child Behavior Checklist/4–18 and Profile. Burlington, VT: University of Vermont, Department of Psychiatry; 1991.

Albert D, Chein J, Steinberg L. The teenage brain peer influences on adolescent decision making. Current Directions in Psychological Science. 2013; 22:114–120.10.1177/0963721412471347 [PubMed: 25544805]

Anderson P. Assessment and development of executive function during childhood. Child Neuropsychology. 2002; 8:71–82.10.1076/chin.8.2.71.8724 [PubMed: 12638061]

Anzai Y, Simon H. The theory of learning by doing. Psychological Review. 1979; 86:124–140.10.1037/0033-295X.86.2.124 [PubMed: 493441]

Archer J. Sex differences in aggression in real-world settings: a meta-analytic review. Review of General Psychology. 2004; 8:291–322.10.1037/1089-2680.8.4.291

Asher SR, Hymel S, Renshaw P. Loneliness in children. Child Development. 1984; 55:1456–1464.10.2307/1130015

Balaraman, GR. Children's self-regulation and peer interaction at 36 and 54 months: concurrent and longitudinal relations. Paper presented at the Biennial Meeting of the Society for Research in Child Development; Tampa, Florida. 2003.

Barkley, RA. The assessment of attention in children. In: Lyon, GR., editor. Frames of reference for the assessment of learning disabilities: new views on measurement issues. Baltimore, Maryland: Brookes Publishing Company; 1994. p. 69-102.

Bateson, P. The nature of play: great apes and humans. New York, NY: Guilford Press; 2005. The role of play in the evolution of great apes and humans; p. 13-24.

Bentler PM. Comparative fit indexes in structural models. Psychological Bulletin. 1990; 107:238–246.10.1037/0033-2909.107.2.238 [PubMed: 2320703]

Berg KW, Byrd DL. The Tower of London spatial problem-solving task: enhancing clinical and research implementations. Journal of Clinical Experimental Neuropsychology. 2002; 24:586–605.10.1076/jcen.24.5.586.1006 [PubMed: 12187443]

Berkman ET, Graham AM, Fisher PA. Training self-control: a domain-general translational neuroscience approach. Child Development Perspectives. 2012; 6:374–384.10.1111/j.1750-8606.2012.00248.x [PubMed: 23894251]

Berlin L, Bohlin G. Response inhibition, hyperactivity, and conduct problems among preschool children. Journal of Clinical Child and Adolescent Psychology. 2002; 31:242–251.10.1207/S15374424JCCP3102_09 [PubMed: 12056107]

Berlyne, DE. Conflict, Arousal, and Curiosity. New York, NY: McGraw Hill; 1960.

Bierman KL, Domitrovich CE, Nix RL, Gest SD, Welsh JA, Greenberg MT, Gill S. Promoting academic and social-emotional school readiness: the Head Start REDI program. Child Development. 2008; 79:1802–1817.10.1111/j.1467-8624.2008.01227.x [PubMed: 19037951]

Bierman KL, Montminy HP. Developmental issues in social-skills assessment and intervention with children and adolescents. Behavior Modification. 1993; 17:229–254.10.1177/01454455930173002 [PubMed: 8343098]

Bouman T, van der Meulen M, Goossens FA, Olthof T, Vermande MM, Aleva EA. Peer and self-reports of victimization and bullying: their differential association with internalizing problems and social adjustment. Journal of School Psychology. 2012; 50:759–774.10.1016/j.jsp.2012.08.004 [PubMed: 23245499]

Brocki KC, Bohlin G. Executive functions in children aged 6 to 13: a dimensional and developmental study. Developmental Neuropsychology. 2004; 26:571–593.10.1207/s15326942dn2602_3 [PubMed: 15456685]

Browne, MW.; Cudeck, R. Alternative ways of assessing model fit. In: Bollen, K.; Long, S., editors. Testing Structural Equation Models. Beverly Hills, CA: Sage; 1993. p. 136-162.

Burford HC, Foley LA, Rollins PG, Rosario KS. Gender differences in preschoolers' sharing behavior. Journal of Social Behavior and Personality. 1996; 11:17–25.

Carlson SM, Moses LJ. Individual differences in inhibitory control and children's theory of mind. Child Development. 2001; 72:1032–1053.10.1111/1467-8624.00333 [PubMed: 11480933]

Cillessen AHN, Rose AJ. Understanding popularity in the peer system. Current Directions in Psychological Science. 2005; 14:102–105.10.1111/j.0963-7214.2005.00343.x

Cillessen, AHN.; Terry, RA.; Coie, JD.; Lochman, JE. Accuracy of teacher-identification of children's sociometric status positions. Paper presented at the Conference on Human Development; Atlanta, GA. 1992.

Coplan, RJ.; Arbeau, KA. Handbook of Peer Interactions, Relationships, and Groups. New York: Guilford Press; 2009. Peer interactions and play in early childhood; p. 143-161.

Crick NR. Engagement in gender normative versus nonnormative forms of aggression: links to social–psychological adjustment. Developmental Psychology. 1997; 33:610–617.10.1037/0012-1649.33.4.610 [PubMed: 9232376]

David KM, Murphy BC. Interparental conflict and preschoolers' peer relations: the moderating roles of temperament and gender. Social Development. 2007; 16:1–23.10.1111/j.1467-9507.2007.00369.x

Deater-Deckard K. Recent research examining the role of peer relationships in the development of psychopathology. Journal of Child Psychology and Psychiatry. 2001; 42:565–579.10.1111/1469-7610.00753 [PubMed: 11464962]

Domitrovich CE, Cortes RC, Greenberg MT. Improving young children's social and emotional competence: a randomized trial of the preschool "PATHS" curriculum. The Journal of Primary Prevention. 2007; 28:67–91.10.1007/s10935-007-0081-0 [PubMed: 17265130]

Eisenberg N, Fabes RA, Nyman M, Bernzweig J, Pinuelas A. The relations of emotionality and regulation to children's anger-related reactions. Child Development. 1994; 65:109–128.10.1111/j.1467-8624.1994.tb00738.x [PubMed: 8131642]

Espelage, D.; Holt, M. Bullying and victimization during early adolescence: Peer influences and psychosocial correlates. In: Geffner, R.; Loring, M.; Young, C.; Corinna, editors. Bullying Behavior: Current Issues, Research, and Interventions. Binghamton, NY: Haworth Maltreatment and Trauma Press/The Haworth Press; 2001. p. 123-142.

Fabes RA, Eisenberg N, Jones S, Smith M, Guthrie I, Poulin R, Friedman J. Regulation, emotionality, and preschoolers' socially competent peer interactions. Child Development. 1999; 70:432–442.10.1111/1467-8624.00031 [PubMed: 10218264]

Fabes RA, Martin CL, Hanish LD. Young children's play qualities in same-, other-, and mixed-sex peer groups. Child Development. 2003; 74:921–932.10.1111/1467-8624.00576 [PubMed: 12795398]

Fabes, RA.; Martin, CL.; Hanish, LD. Handbook of Peer Interactions, Relationships, and Groups. New York: Guilford Press; 2009. Children's behaviors and interactions with peers; p. 45-62.

Fahie CM, Symons DK. Executive functioning and theory of mind in children clinically referred for attention and behavior problems. Journal of Applied Developmental Psychology. 2003; 24:51–73.10.1016/S0193-3973(03)00024-8

Farley JP, Kim-Spoon J. The development of adolescent self-regulation: Reviewing the role of parent, peer, friend, and romantic relationships. Journal of Adolescence. 2014; 37:433–440.10.1016/j.adolescence.2014.03.009 [PubMed: 24793391]

Gunnar MR, Sebanc AM, Tout K, Donzella B, van Dulmen MM. Peer rejection, temperament, and cortisol activity in preschoolers. Developmental Psychobiology. 2003; 43:346–368.10.1002/dev.10144 [PubMed: 15027418]

Hay, DF.; Caplan, M.; Nash, A. Handbook of Peer Interactions, Relationships, and Groups. New York: Guilford Press; 2009. The beginnings of peer relations; p. 121-142.

Hay DF, Castle J, Davies L, Demetriou H, Stimson CA. Prosocial action in very early childhood. Journal of Child Psychology and Psychiatry. 1999; 40:905–916. [PubMed: 10509885]

Hay DF, Payne A, Chadwick A. Peer relations in childhood. Journal of Child Psychology and Psychiatry. 2004; 45:84–108.10.1046/j.0021-9630.2003.00308.x [PubMed: 14959804]

Henry DB. Associations between peer nominations, teacher ratings, self-reports, and observations of malicious and disruptive behavior. Assessment. 2006; 13:241–252.10.1177/1073191106287668 [PubMed: 16880277]

Hughes C, Dunn J, White A. Trick or treat: uneven understanding of mind and emotion and executive dysfunction in "hard-to-manage" preschoolers. Journal of Child Psychology and Psychiatry. 1998; 39:981–994.10.1111/1469-7610.00401 [PubMed: 9804031]

Hughes C, Ensor R. Executive function and theory of mind: predictive relations from ages 2 to 4. Developmental Psychology. 2007a; 43:1447–1459.10.1037/0012-1649.43.6.1447 [PubMed: 18020823]

Hughes C, Ensor R. Positive and protective: effects of early theory of mind on problem behaviors in at-risk preschoolers. Journal of Child Psychology and Psychiatry. 2007b; 48:1025–1032.10.1111/j.1469-7610.2007.01806.x [PubMed: 17915003]

Hughes C, Ensor R. Individual differences in growth in executive function across the transition to school predict externalizing and internalizing behaviors and self-perceived academic success at 6 years of age. Journal of Experimental Child Psychology. 2011; 108:663–676.10.1016/j.jecp.2010.06.005 [PubMed: 20673580]

Iyer RV, Kochenderfer-Ladd B, Eisenberg N, Thompson M. Peer victimization and effortful control: relations to school engagement and academic achievement. Merrill-Palmer Quarterly. 2010; 56:361–387.10.1353/mpq.0.0058 [PubMed: 23105166]

Jacques S, Zelazo PD, Kirkham NZ, Semcesen TK. Rule selection versus rule execution in preschoolers: an error-detection approach. Developmental Psychology. 1999; 35:770–780.10.1037/0012-1649.35.3.770 [PubMed: 10380867]

Johnson SB, Blum RW, Giedd JN. Adolescent maturity and the brain: the promise and pitfalls of neuroscience research in adolescent health policy. Journal of Adolescent Health. 2009; 45:216–221.10.1016/j.jadohealth.2009.05.016 [PubMed: 19699416]

Kim J, Deater-Deckard K. Dynamic changes in anger, externalizing and internalizing problems: attention and regulation. Journal of Child Psychology and Psychiatry. 2011; 52:156–166.10.1111/j.1469-7610.2010.02301.x [PubMed: 20825522]

Kochel, KP.; McConnell, EM.; Ladd, GW. Do negative peer relationships provoke other peer adversities?. Poster presented at the meeting for the Society for Research in Child Development; Boston, MA. 2007.

Kochenderfer-Ladd B, Troop-Gordon W. Contexts, causes, and consequences: new directions in peer victimization research. Merrill-Palmer Quarterly. 2010; 56:221–230.10.1353/mpq.0.0048

Ladd GW. Social networks of popular, average, and rejected children in school settings. Merrill-Palmer Quarterly. 1983; 29:283–307.

Ladd, GW. Children's peer relations and social competence: a century of progress. Yale University Press; 2005.

Ladd, GW. Handbook of Peer Interactions, Relationships, and Groups. New York: Guilford Press; 2009. Trends, travails, and turning points in early research on children's peer relationships: legacies and lessons for our time; p. 20-41.

Ladd GW, Profilet SM. The Child Behavior Scale: a teacher-report measure of young children's aggressive, withdrawn, and prosocial behaviors. Developmental Psychology. 1996; 32:1008–1024.10.1037/0012-1649.32.6.1008

Lindsey EW, Colwell MJ. Preschoolers' emotional competence: Links to pretend and physical play. Child Study Journal. 2003; 33:39–52.

Lopes PN, Salovey P, Côté S, Beers M. Emotion regulation abilities and the quality of social interaction. Emotion. 2005; 5:113–118.10.1037/1528-3542.5.1.113 [PubMed: 15755224]

Maszk P, Eisenberg N, Guthrie IK. Relations of children's social status to their emotionality and regulation: a short-term longitudinal study. Merrill-Palmer Quarterly. 1999; 45:468–492.

Mathur R, Berndt TJ. Relations of friends' activities to friendship quality. The Journal of Early Adolescence. 2006; 26:365–388.10.1177/0272431606288553

McKown C, Gumbiner LM, Russo NM, Lipton M. Social-emotional learning skill, self-regulation, and social competence in typically developing and clinic-referred children. Journal of Clinical Child & Adolescent Psychology. 2009; 38:858–871.10.1080/15374410903258934 [PubMed: 20183669]

Miyake A, Friedman NP. The nature and organization of individual differences in executive functions four general conclusions. Current Directions in Psychological Science. 2012; 21:8–14.10.1177/0963721411429458 [PubMed: 22773897]

Muthén, LK.; Muthén, BO. Mplus User's Guide. 7. Los Angeles, CA: Muthén & Muthén; 2010.

Nelson LJ, Rubin KH, Fox NA. Social withdrawal, observed peer acceptance, and the development of self-perceptions in children ages 4 to 7 years. Early Childhood Research Quarterly. 2005; 20:185–200.10.1016/j.ecresq.2005.04.007

Parker, JG.; Rubin, KH.; Erath, SA.; Wojslawowicz, JC.; Buskirk, AA. Peer relationships, child development, and adjustment: a developmental psychopathology perspective. In: Cicchetti, D.; Cohen, DJ., editors. Developmental Psychopathology, Vol 1: Theory and method. 2. Hoboken, NJ, US: John Wiley & Sons Inc; 2006. p. 419-493.

Peterson, JB.; Flanders, JL. Developmental Origins of Aggression. New York, NY: Guilford Press; 2005. Play and the regulation of aggression; p. 133-157.

Power, TG. Play and exploration in children and animals. Manwah, NJ: Erlbaum; 2000.

Rose, AJ.; Smith, RL. Handbook of Peer Interactions, Relationships, and Groups. New York: Guilford Press; 2009. Sex differences in peer relationships; p. 379-393.

Rothbart MK, Ahadi SA, Hershey KL. Temperament and social behavior in childhood. Merrill-Palmer Quarterly. 1994; 40:21–39.

Rubin KH, Bukowski WM, Parker JG. Peer interactions, relationships, and groups. Handbook of Child Psychology. 199810.1002/9780470147658.chpsy0310

Rushton JP, Brainerd CJ, Pressley M. Behavioral development and construct validity: the principle of aggregation. Psychological Bulletin. 1983; 94:18–38.10.1037/0033-2909.94.1.18

Russ SW, Robins AL, Christiano BA. Pretend play: longitudinal prediction of creativity and affect in fantasy in children. Creativity Research Journal. 1999; 12:129–139.10.1207/s15326934crj1202_5

Sebanc AM, Pierce SL, Cheatham CL, Gunnar MR. Gendered social worlds in preschool: dominance, peer acceptance and assertive social skills in boys' and girls' peer groups. Social Development. 2003; 12:91–106.10.1111/1467-9507.00223

Stenseng F, Belsky J, Skalicka V, Wichstrøm L. Social exclusion predicts impaired self-regulation: a 2-year longitudinal panel study including the transition from preschool to school. Journal of Personality. 2014; 83:212–220.10.1111/jopy.12096 [PubMed: 24635533]

Sturaro C, Van Lier PA, Cuijpers P, Koot HM. The role of peer relationships in the development of early school-age externalizing problems. Child Development. 2011; 82:758–765.10.1111/j.1467-8624.2010.01532.x [PubMed: 21410917]

Turner ML, Engle RW. Is working memory capacity task dependent? Journal of Memory and Language. 1989; 28:127–154.10.1016/0749-596X(89)90040-5

Walden TA, Smith MC. Emotion Regulation. Motivation and Emotion. 1997

Walker S, Berthelsen DC, Irving KA. Temperament and peer acceptance in early childhood: sex and social status differences. Child Study Journal. 2001; 31:177–192.

Welsh MC, Pennington BF, Groisser DB. A normative-developmental study of executive function: a window on prefrontal function in children. Developmental Neuropsychology. 1991; 7:131–149.10.1080/87565649109540483

Woodcock, RW.; Johnson, MB. Woodcock-Johnson Psycho-Educational Battery – Revised. Allen, TX: DLM; 1989.

Youngblade LM, Dunn J. Individual differences in young children's pretend play with mother and sibling: links to relationships and understanding of other people's feelings and beliefs. Child Development. 1995; 66:1472–1492.10.1111/j.1467-8624.1995.tb00946.x [PubMed: 7555225]

Zelazo PD, Frye D, Rapus T. An age-related dissociation between knowing rules and using them. Cognitive Development. 1996; 11:37–63.10.1016/S0885-2014(96)90027-1

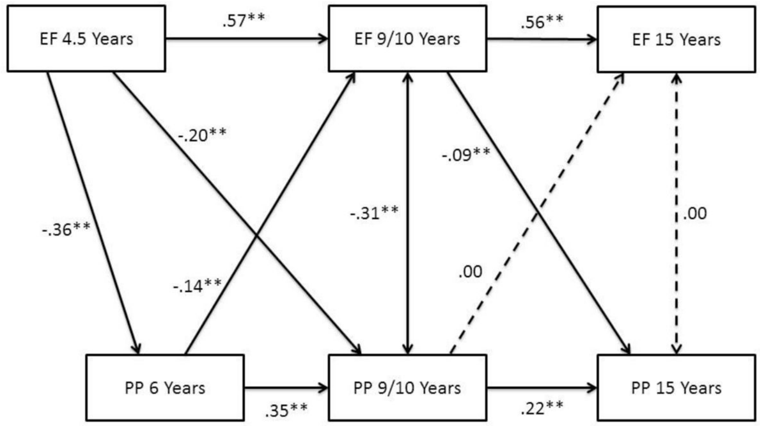

Figure 1.

Maximum likelihood estimation (standardized coefficients) of longitudinal relations among executive function (EF) and peer problems (PP).

* $p \leq .05$, ** $p \leq .01$

Table 1

Bivariate correlations of measures of executive function

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Attention focusing 4.5	-												
2. Inhibitory control 4.5	.63**	-											
3. Attention problems 4.5	.41**	.46**	-										
4. Continuous Performance Task 4.5	.20**	.21**	.18**	-									
5. Woodcock-Johnson memory 4.5	.26**	.22**	.16**	.25**	-								
6. Attention problems 9	.37**	.39**	.52**	.17**	.19**	-							
7. Tower of Hanoi 9	.18**	.22**	.20**	.26**	.24**	.22**	-						
8. Woodcock-Johnson memory 9	.28**	.24**	.16**	.20**	.55**	.23**	.28**	-					
9. Continuous performance task 10	.11**	.12**	.12**	.23**	.18**	.10**	.21**	.24**	-				
10. Attention problems 10	.35**	.39**	.49**	.18**	.19**	.78**	.22**	.21**	.11**	-			
11. Attention problems 15	.28**	.29**	.40**	.16**	.12**	.60**	.17**	.16**	.11**	.61**	-		
12. Operation Span task 15	.14**	.13**	.09**	.16**	.34**	.12**	.22**	.44**	.15**	.12**	.10**	-	
13. Tower of London 15	.12**	.08*	.13**	.13**	.19**	.09**	.26**	.22**	.09*	.09**	.03	.18**	-

Note: All scales coded in same direction such that higher scores indicated higher executive function;

* $p \leq .05$,

** $p \leq .01$ (two-tailed).

Table 2

Bivariate correlations of measures of peer problems

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1. Friends or foes 4.5 (Teacher)	-										
2. Friends or foes 4.5 (ASCG)	.33**	-									
3. Sociometric status 4.5 (Teacher)	.71**	.31**	-								
4. Sociometric status 4.5 (ASCG)	.38**	.67**	.36**	-							
5. Child behavior with peers 9 (Teacher)	.29**	.34**	.31**	.32**	-						
6. Child behavior with peers 9 (ASCG)	.28**	.35**	.37**	.11	.31**	-					
7. Child behavior with peers 10 (Teacher)	.34**	.20*	.36**	.17*	.46**	.35**	-				
8. Child behavior with peers 10 (ASCG)	.28**	.32*	.33**	.15	.48**	.38**	.41**	-			
9. Loneliness & social dissatisfaction 15 (Self)	.16**	.12	.12**	.07	.11**	.06	.18**	.25**	-		
10. What my peers think about me 15 (Self)	.10**	.04	.13**	.07	.08**	.22**	.13**	.12	.22**	-	
11. Peer relationships 15 (Self)	.13**	.08	.15**	.08	.16**	.14*	.17**	.07	.38**	.40**	-

Note: All scales coded in same direction such that higher scores indicated higher peer problems; ASCG = after school caregiver

* $p \leq .05$,

** $p \leq .01$ (two-tailed).

Table 3

Longitudinal bivariate correlations and descriptive statistics for executive function and peer problems

Variables	**1**	**2**	**3**	**4**	**5**	**6**	***M***	***SD***
1. EF 4.5 Years	-						.00	1.00
2. EF 9/10 Years	.61**	-					.00	1.00
3. EF 15 Years	.44**	.55**	-				.00	1.00
4. PP 6 Years	−.36**	−.34**	−.20**	-			.00	1.00
5. PP 9/10 Years	−.32**	−.45**	−.23**	.40**	-		.00	1.00
6. PP 15 Years	−.12**	−.18**	−.10**	.19**	.24**	-	.00	1.00

Note: EF = executive function, PP = peer problems,

* $p \leq .05$,

** $p \leq .01$ (two-tailed).