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Direct and Indirect Effects of the Family Check-Up on Self-Regulation from Toddlerhood to Early School-Age

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Abstract

We examined the development of children's inhibitory control from toddlerhood to early school-age (i.e., ages 2 to 7.5 years), investigated the effects of the Family Check-Up on the growth of inhibitory control, and explored whether such effects transferred to the school context. Participants were 731 low-income children (49 % female). Results indicated that parental reports of inhibitory control showed positive, nonlinear increase with the growth decelerating over time. Moreover, children in the intervention condition demonstrated higher levels of growth in parental ratings of inhibitory control compared to the control condition. More importantly, the intervention had indirect effects on teacher reports of children's self-control and oppositional defiant behavior as well as examiner ratings of self-control through its promotion of growth in inhibitory control. The findings are discussed with respect to implications for more specifically targeting the promotion of self-regulation in early childhood in addition to reduction in early problem behavior.

Keywords

Inhibitory control; Self-regulation; Family intervention; Preschool

Self-regulation plays a key role in many aspects of adaptive development and psychopathology including school readiness (e.g., Blair 2002) and externalizing behavior (e.g., Kochanska and Knaack 2003). In particular, the ability to self-regulate has been highlighted as an important protective factor among children at risk for psychopathology (Buckner et al. 2003). Self-regulation is composed of multiple abilities that contribute to the modulation of behavior and affect in response to contextual demands (Posner and Rothbart 2000). One core component of self-regulation is inhibitory control (IC), which is the capacity to suppress inappropriate behavioral responses (Posner and Rothbart 2000). IC has also been implicated in models of executive function (Garon et al. 2008) and temperamental effortful control (Rothbart and Bates 2006). Although it is generally known that IC develops

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rapidly in early childhood (Rothbart and Bates 2006), few studies have modeled the longitudinal growth trajectory of IC across multiple years (Dennis et al. 2007; Li-Grining 2007; Moilanen et al. 2010a; Raikes et al. 2007). More importantly, to our knowledge, no study to date has examined the development of IC from the toddler period through early school-age at more than three points in time. Such data would be beneficial for tracing its developmental course from early to middle childhood, and could be informative for developing interventions to prevent problem behaviors associated with deficits in self-regulation.

In addition, based on the significance of self-regulation for a wide range of child outcomes, it would be important to investigate whether children's IC can be promoted as a result of early intervention. Despite the fact that a number of school-based programs have targeted self-regulation in their intervention protocols, relatively few studies have documented intervention effects on children's emerging IC or self-regulation, particularly beginning as early as the toddler period. It is perhaps surprising that many curricula to promote self-regulation abilities have focused on school-age children rather than toddlers and preschoolers, as the foundation of regulatory abilities develops during early childhood, including IC (Rothbart and Bates 2006). One of the few exceptions to the lack of focus on promoting children's adjustment through early home-based programs prior to the school-age and even the preschool period is the Family Check-Up (FCU). The FCU is a family-centered intervention that has previously been used successfully with adolescents (Connell et al. 2007; Dishion et al. 2002), and has recently been validated with toddlers at risk for early problem behavior (Dishion et al. 2008; Shaw et al. 2006). Recent findings also suggest that the FCU may promote positive qualities in children such as self-regulation. Specifically, the intervention was found to be related to positive changes in IC from 3 to 4 years, an effect that was mediated by changes in parenting behavior (Lunkenheimer et al. 2008). However, it remains unclear whether the effects of the FCU on IC may span from early to middle childhood and whether such effects may transfer to the school context.

The aims of this study were to examine the developmental trajectory of IC from toddlerhood to early school-age (i.e., 2 to 7.5 years), and to investigate whether the FCU would facilitate the growth of IC during this period. A final goal was to examine if intervention effects on IC, evident based on parental reports, generalized across context and outcome, using teacher and examiner ratings of children's self-control and oppositional defiant behavior at age 7.5 years.

The Development of Inhibitory Control

Inhibitory control (IC) in children emerges after 2 years of age, developing rapidly during the preschool period in concert with the maturation of the anterior cingulate region in the brain that is implicated in executive function (Posner and Rothbart 2000; Rothbart and Bates 2006). It has also been suggested that the growth of IC slows down after age 4 (Jones et al. 2003). Studies examining the development of IC have typically used rank-order stability and have consistently found IC to be moderately stable over time (e.g., Kochanska and Knaack 2003).

Relatively few studies have observed mean-level changes in children's IC with a few notable exceptions. For example, in Head Start children aged 14 to 36 months, examiner ratings of self-regulation during a testing situation (which includes but is not limited to IC abilities) demonstrated a positive, nonlinear increase over time with the growth accelerating at later ages (Raikes et al. 2007). In another study of low-income children between the ages of 2 and 4 years, IC measured by a delay of gratification task improved over the course of 16 months, with greater growth for younger children (Li-Grining 2007). Further, in a sample of children at risk for psychopathology, a Suppress/Initiate factor of effortful control (a construct that conceptually overlaps with IC), assessed with a behavioral battery, showed positive, nonlinear development from ages 4 to 6 years, with steeper growth between 4 and 5 years than between 5 and 6 years (Dennis et al. 2007). Finally, in the current sample, linear growth in IC was found from ages 2 to 4 years (Moilanen et al. 2010a). Together, research suggests that children may follow a positive, nonlinear trajectory of IC in early childhood, with a marked increase occurring during the preschool years. However, no study has yet traced child IC from early to middle childhood at more than three points in time and linked these improvements to school outcomes.

Inhibitory Control and Early School Adjustment

Children's early IC is predictive of their positive adjustment in school, including lower levels of disruptive behavior such as defiance, hostility, and noncompliance (Kochanska and Knaack 2003; Rimm-Kaufman et al. 2009). Although the transition to school is challenging for all children, it may be particularly difficult for those who have had low levels of early IC because the task demands require considerable self-regulation in the child (Blair 2002). Moreover, children's disruptive behavior in the early elementary years forecasts their continued difficulty in socioemotional and academic domains (Moilanen et al. 2010b), and predicts long-term outcomes such as arrests for delinquent behavior (Loeber and Dishion 1983). Therefore, less growth of early IC may be an important marker of later maladjustment, including antisocial behavior.

Early Family Intervention and Inhibitory Control

Family-based interventions may promote child self-regulation indirectly by improving parenting practices that support children's acquisition of regulatory skills (e.g., maternal sensitivity, autonomy support; Bernier et al. 2010). Through these programs, parents may also learn to better regulate their impulses that may positively impact children's self-regulation through improved family management as well as by imitation (Forman and Kochanska 2001; Patterson et al. 1992). A family-based approach may be particularly valuable in early childhood when caregivers play a large role in children's socialization. Indeed, parenting-focused curricula have been found to enhance positive parenting skills and reduce child disruptive behavior (e.g., Gross et al. 2003).

However, little is known about parenting-focused interventions' ability to promote children's self-regulation skills with a few exceptions. For example, the Incredible Years parent training program has been found to enhance children's prosocial behavior (Menting et al. 2013), which heavily relies on the ability to self-regulate. The prevention model used

in this study is the Family Check-Up (FCU). Although the focus of the FCU was primarily on reducing child conduct problems rather than promoting positive attributes such as self-regulation, documented linkages between parenting practices and children's regulatory skills raise a question as to whether the FCU may indirectly facilitate children's self-regulation through its effects on parenting. Indeed, as described earlier, Lunkenheimer and colleagues (2008) have documented initial effects of the FCU on children's emerging IC between ages 3 and 4 years.

The FCU is an ecological, family-centered intervention (Dishion and Stormshak 2007) that incorporates motivational interviewing to stimulate parents to modify caregiving practices (Miller and Rollnick 2002). There are a few unique features of this model. First, intervention is heavily driven by a thorough assessment of the child's family and community ecology. A comprehensive understanding of the child and family is vital in making decisions about how to tailor services to individual family's needs. Second, a structured feedback is provided to the family based on results from the assessment, highlighting both family strengths and potential areas of improvement. Depending on the family's needs and motivation to change, parents are offered an opportunity to engage in additional intervention in varying formats (e.g., therapy sessions, phone check-ups, community referrals), an aspect that differs from many conventional programs with a standard curriculum for all parents referred to as the Everyday Parenting curriculum (Dishion et al. 2011). The follow up sessions within FCU are consistent with parent management training protocols, the evidence base for which is detailed by Forgatch and Patterson (2010). Therefore, the FCU is typically brief with most families participating in two or three sessions. Third, in contrast to more traditional clinical models, the FCU is grounded in a health maintenance perspective, involving periodic contact with the families (i.e., once a year) to support parenting strengths as well as addressing specific parenting needs through multiple developmental transitions.

The FCU has been applied with adolescent-age samples and found to significantly reduce antisocial behavior, depression, substance use, and probability of arrest (Connell et al. 2007; Dishion et al. 2002). In a more recent trial of the FCU in early adolescence, it was found that random assignment to the FCU resulted in higher levels of youth effortful control in the intervention group compared to the control group, which mediated the relation between the FCU and depression and school engagement (Stormshak et al. 2010). Recently, the FCU has been adapted for use during early childhood and shown to be associated with reductions in children's disruptive and emotional problem behaviors from ages 2 to 4 in two independent samples of at-risk toddlers (Dishion et al. 2008; Shaw et al. 2009; Shaw et al. 2006). Further, children in the intervention condition showed lower levels of teacher-rated oppositional defiant behavior than those in the control condition at early school-age (Dishion et al. 2014). However, it is yet unclear whether improvement in children's self-regulation may mediate the FCU's effects on school adjustment as found in the adolescent sample (Stormshak et al. 2010).

The Present Study

As reviewed, although IC has been recognized as a significant contributor to child functioning, relatively little is known about its course of development from early to middle

childhood. Moreover, few studies have investigated the potential intervention effects of early preventive programs on young children's developing IC, including those focused on modifying parenting practices. As a follow up of earlier studies using the current sample when children were younger (Lunkenheimer et al. 2008; Moilanen et al. 2010a), this study aimed to examine the growth of IC from toddlerhood to early school-age (i.e., 2 to 7.5 years), and to test whether the FCU facilitates its development. We also investigated whether one mechanism for the FCU's effects on reducing children's disruptive behavior at school may involve facilitated growth in their ability to self-regulate.

Although child IC has been measured in multiple ways in previous studies, and ideally would involve obtaining convergence across laboratory observations and parental reports, we relied on maternal reports of IC in this study with an expectation that mothers would be able to provide valid information on child behavior especially in the early years when children spend more time in the home than in the later years. Moreover, as a requisite for growth modeling, we needed a source of data that would not change in method or informant over time. Despite the reliance on one informant and one method to assess IC, we were able to evaluate the generalizability of the intervention effects on IC across context, informant, and outcome by incorporating children's self-control and oppositional defiant behavior rated by teachers at age 7.5 years. Although IC and self-control share conceptual similarities, we believed it was worthwhile to examine if behavior change observed in the home by parents would be evident at school as reported by teachers. Thus, the measurement of self-control observed by teachers at school provided an additional test of the FCU's effectiveness in promoting children's regulatory behavior. Furthermore, examiner ratings of children's self-control at the age-7.5 assessment were incorporated to corroborate teacher data, which were available for only a subset of the sample.

It was hypothesized that child IC would show a nonlinear development with accelerated growth during the preschool period. Additionally, we expected that the FCU would facilitate the growth of IC and that improvement in IC would mediate the effects of the FCU on reduced levels of child oppositional defiant behavior and increased levels of child self-control at school. It was also anticipated that similar findings would emerge for examiner ratings of child self-control at 7.5 years. Data were used from the Early Steps Project, a multisite prevention program for toddlers at risk for conduct problems who were living in predominantly low-income families. Children of economically disadvantaged families are likely to be exposed to a set of stressors that negatively impacts their neurological, cognitive, and affective development, including self-regulatory abilities (Raver 2004). Therefore, using the current sample provided an opportunity to examine the early development of IC among children at higher risk for poor self-regulation.

Method

Participants

Participants were 731 families recruited from Women, Infant, and Children (WIC) Clinics in Pittsburgh, Pennsylvania, Eugene, Oregon, and Charlottesville, Virginia (Dishion et al. 2008). Families were invited to participate in a randomized prevention trial for early problem behavior if they had a son or daughter aged 2 years 0 months to 2 years 11 months,

following a screen to ensure that they met the study criteria by having socioeconomic, family, and/or child risk factors for future behavior problems (For more details, see Dishion et al. 2008).

Children (49 % female) had a mean age of 29.9 months (*SD*=3.2) at the time of the age-2 assessment. Across sites, children were predominantly European American (50 %) and African American (28 %), with smaller numbers of biracial children (13 %) and children from other racial and ethnic backgrounds (e.g., Asian American, Native American; 9 %). During the period of screening from 2002 to 2003, more than two thirds of families had an annual income of less than $20,000. Forty-one percent of the primary caregivers (97 % mothers) had a high school diploma or GED equivalency and 24 % had less than high school education. With respect to family constellation, 58 % of children lived in a two-parent household (i.e., married or living together). The research protocol was approved by the respective universities' Institutional Review Boards, and participating families provided informed consent.

Retention—Of the 731 families who initially participated, 662 (91 %), 627 (86 %), 621 (85 %), and 568 (78 %) were available at the follow-up at ages 3, 4, 5, and 7.5 years, respectively. Selective attribution analyses revealed that families with significantly lower levels of parental education were more likely to drop out of the study at subsequent assessments: at age 3, $F(1, 730)=5.24$, $p<0.05$; age 4, $F(1, 730)=10.76$, $p<0.01$; age 5, $F(1, 730)=15.81$, $p<0.001$; and age 7.5, $F(1, 730)=11.08$, $p<0.01$. There were no significant differences in attrition by project site, intervention status, children's race, ethnicity, or gender, levels of maternal depression, or children's IC or externalizing behavior. Seven hundred and twenty children had sufficient data to be included in growth modeling analyses (i.e., the child had at least one report of IC at any time). At 7.5 years, teacher data were available for only 314 participants, primarily due to difficulties in obtaining cooperation at two of the largest school systems, which significantly reduced retention of school data in those sites. Of the 560 families who were retained at age 7.5 years, 56 % had teacher ratings available (site 1=39 %, site 2=60 %, site 3=69 %). In addition to site, no significant differences were found between families with versus without teacher data in demographic or other study variables. Despite the missing data, teacher reports were included in the analysis to explore whether the intervention effects on IC, if present, generalized across context and informant. Further, we tried to corroborate teacher findings by incorporating examiner ratings (n=528) which were available for 94 % of the sample assessed at age 7.5 years.

Procedure

Assessment Protocol—At child age 2 years, parents who agreed to participate in the study were scheduled for a 2.5-hour home visit. Each assessment began by introducing children to an assortment of age-appropriate toys and having them play for 15 min while the primary caregivers completed questionnaires. After free play, a series of parent–child interactive tasks were administered (e.g., clean-up task, delay of gratification, teaching tasks). Similar procedures were repeated at ages 3, 4, 5, and 7.5 years, with minor modifications made to adjust for the developmental status of the child. Additionally, at 7.5

years, teachers completed a battery of questionnaires about the target child. Families and teachers were compensated for their time.

The randomization sequence was computer generated by a member of the staff who was not involved with recruitment. Randomization was balanced by gender to assign an equal number of boys and girls in the control and intervention groups. To ensure blindness, the examiner opened a sealed envelope to reveal the family's intervention status only after the age-2 assessment was completed and then shared this information with the family. Examiners carrying out followup assessments were not informed of the family's assigned condition.

Intervention protocol: The Family Check-Up (FCU)—Families randomly assigned to the intervention condition were scheduled to meet with a parent consultant for two or more sessions, depending on the family's preference. Parent consultants typically held the equivalent or more of a Masters' level degree in counseling or social work, with some prior experience working with families. After the initial assessment as described earlier, the parent consultant met with the family for a "get to know you" (GTKY) session during which parent concerns were explored, focusing on family issues most critical to the child's functioning. The third meeting involved a feedback session during which the parent consultant used motivational interviewing techniques to share the results of the assessment, highlighting areas of family strength as well as areas in need of attention. The parent was offered the choice to participate in follow-up sessions that were focused on parenting and other family issues. The intervention group was asked to participate in the FCU after annual assessment at child ages 2, 3, 4, and 5 years. The majority of the families in the intervention condition agreed to engage in 1 or more sessions of the Everyday Parenting curriculum (Dishion et al. 2011). Families randomized to the control condition completed initial assessments with research staff but had no further contact with clinical staff (i.e., parent consultants) for GTKY, feedback, or follow-up sessions (For more details on the FCU, see Dishion et al. 2008).

Families in the intervention condition were considered to have engaged in the FCU at a given age if they participated in at least a GTKY and feedback session. Although this is an at-risk community sample involving families not requesting clinical services, many of the families accepted the invitation to participate in the FCU, and of those who did, a majority also engaged in some form of follow-up interventions. The following are the proportion of participants who had an assessment at each age and (a) engaged in an FCU feedback session, (b) engaged in follow-up sessions, and (c) in parentheses, the average number of follow-up sessions, respectively: age 2: 76 %, 72 % (3.4, range=0–32); age 3: 69 %, 70 % (3.1, range 0–48); age 4: 70 %, 74 % (3.5, range=0–41); age 5: 66 %, 68 % (3.6, range=0–77). Overall, of the 367 families in the intervention condition, a total of 324 (88.3 %) engaged in the FCU at least once between ages 2 and 5 years. We used an intention-to-treat (ITT) design for all analyses, including the 11.7 % of families in the intervention group who chose not to take part in the FCU at any time.

Measures

Demographic Questionnaire—A demographic questionnaire for primary caregivers included questions about parental education and income, family structure, and child ethnicity. Parental education was assessed on a scale of 1 (*no formal schooling*) to 9 (*graduate degree*).

Inhibitory Control—The 13-item Inhibitory Control subscale of the Children's Behavior Questionnaire (CBQ; Rothbart et al. 1994) was used to measure children's ability to suppress immediate behavioral reactions. Primary caregivers rated each item (e.g., "can easily stop an activity when s/he is told 'no.'") on a 7-point scale (1=*extremely untrue of child*; 7=*extremely true of child*) in reference to their child at ages 2, 3, 4, 5, and 7.5 ($\alpha \geq 0.66$; reported αs for all measures are based on our data). Additionally, we attempted to further validate parental perception of child IC by examining its association with observational measures of IC that were available at ages 3 and 5 years. Maternal reports of IC were significantly, albeit modestly, correlated with observed IC during a delay of gratification task in which the child was asked to wait for a cookie at 3 years ($r=0.21$, $p<0.01$) or a gift at 5 years ($r=0.22$, $p<0.01$). This is consistent with other studies that have documented modest levels of cross-method convergence of child self-regulation (e.g., Olson et al. 2005).

Self-Control—At age 7.5 years, teacher and examiner ratings were used to evaluate children's self-control, a construct that conceptually overlaps with IC. Teachers completed the 10-item Self-Control factor of the Social Skills Ratings Scale (SSRS; Gresham and Elliot 1990), which measures the ability to control emotion and behavior in challenging situations (e.g., "controls temper in conflict situations with peers"; $\alpha=0.91$). Each item was rated on a 3-point scale (0 = *never*; 2 = *very often*) based on the frequency with which it occurs for the target child.

Examiners rated the child's behavior during the administration of the Woodcock-Johnson achievement test (Woodcock et al. 2001) using the Lack of Control subscale from a measure of children's behavior styles (Caspi et al. 1995). We used the Impulsivity/distractibility factor of this subscale based on its similarity to IC (e.g., "The child spends short time with tasks"; $\alpha=0.86$). Each item was rated on a 3-point scale (0 = *not at all*; 2 = *definitely*). The scores were reverse coded so that higher scores represented higher levels of self-control, consistent with teacher ratings of self-control and maternal reports of IC.

It should be noted that there is substantial conceptual overlap between IC and self-control, as both constructs assess the child's ability to regulate behavior. However, self-control is a broader construct than IC in that IC serves as a foundation on which more complex forms of self-control develop (Wills and Dishion 2004). In the current study, IC and self-control were also measured in different contexts using different informants and methods. Specifically, IC between ages 2 and 7.5 years was rated by parents who would most likely have observed the child in relatively unstructured interactions. Conversely, self-control was assessed at age 7.5 years in school by teachers and during a testing session by research staff, both of which

represent more structured contexts than the home. Despite the similarities, the terms IC and self-control were kept distinct for consistency with the factor labels of the original scales.

Oppositional Defiant Behavior—At age 7.5 years, children's oppositional defiant behavior was assessed with the Teacher Report Form (TRF/6–18; Achenbach and Rescorla 2001). Teachers rated each item on a 3-point scale based on the child's behavior. The DSM-oriented narrowband scale of Oppositional Defiant Problems was used in this study (α=0.90) because of our interest in linking the effects of the FCU to children's oppositional and defiant behavior, which more commonly occurs and is more commonly observed by teachers during the early school-age period than overt aggression or other symptoms of disruptive behavior found on the broad-band Externalizing factor. The TRF scores at 7.5 years were only available for 313 children (42.8 % of the full sample). Of these children, 20 (6.4 %) had *T* scores in the borderline clinical range ($65 \leq T \leq 69$) and 24 (7.7 %) had *T* scores in the clinical range ($T > 69$).

Children's oppositional defiant behavior in toddlerhood was also included in the analysis as a covariate. At age 2 years, primary caregivers rated their child's behavior on the Child Behavior Checklist (CBCL/1 ½-5; Achenbach and Rescorla 2000). Consistent with the school outcome, the DSM-oriented narrowband scale of Oppositional Defiant Problems was used (α=0.73). Of 730 children who had CBCL scores available at 2 years, 70 (9.6 %) had *T* scores in the borderline clinical range ($65 \leq T \leq 69$) and 93 (12.7 %) had *T* scores in the clinical range ($T > 69$).

Analysis Plan

Following preliminary analyses (Tables 1 and 2), latent growth models within a structural equation modeling framework were used to examine systematic changes in IC over time. Specifically, latent growth factors are constructed based on repeatedly measured variable of interest by imposing *a priori* factor loadings. Generally, the intercept's factor loadings are uniformly fixed to '1,' whereas the linear slope's loadings are set to correspond to the study's time scale. In the current study, these values are '0' for age 2, '1' for age 3, '2' for age 4, '3' for age 5, and '5.5' for age 7.5 years. If applicable, the quadratic slope's loadings are equal to the squares of the loadings for the linear slope. A quadratic function yields three growth factors: an intercept (i.e., initial status; in this case, IC at age 2), a linear slope, and a quadratic term indicating an acceleration or deceleration in growth. For each factor, the mean describes the average initial score (intercept) or change over time (slopes), and the variance specifies whether there is a significant variability across individuals in the parameter. Lastly, the covariances between the intercept and slope factors were estimated based on prior studies that have found initial levels and the rates of linear growth in IC to be significantly correlated (e.g., Moilanen et al. 2010a; Raikes et al. 2007). Although it was not possible to anticipate whether the linear and the quadratic slopes would covary because no prior study has observed child IC at more than three points in time and thus could not directly test a quadratic growth model, we explored this possibility in our analysis.

As recommended by Singer and Willet (2003), an unconditional model (i.e., a growth model without any covariates) was initially estimated. To determine the functional form that best

describes the observed data, we compared a linear and non-linear function using the chi-square difference test for nested models. If the chi-square difference value between the two models was significant, it indicated that adding a quadratic term significantly improved the fit.

Subsequently, intervention status and demographic covariates (i.e., project site, child gender and ethnicity, and parental education) were included in the model to test whether they were significantly associated with the latent intercept and slope parameters (i.e., conditional model). Reflecting randomization, there was a nonsignificant correlation between treatment status and child IC at baseline (i.e., age 2 years), which supported a decision to fix the path from the FCU to the intercept at zero. We then explored whether the effects of the FCU on child IC based on parental reports transferred across context, informant, and outcome to teachers' ratings of children's self-control and oppositional defiant behavior, and examiner ratings of self-control at 7.5 years. Specifically, self-control and oppositional behavior were regressed onto the growth factors of the IC trajectory. Oppositional defiant behavior rated by parents at 2 years was included to control for earlier variations in behavior problems. If the FCU had significant effects on the growth of IC and the latent slope of IC significantly predicted self-control or oppositional defiant behavior, the indirect effect was tested using MacKinnon (2008)'s approach to see whether the growth in IC mediated the effects of the FCU on child outcomes at 7.5 years.

For all models, Mplus 5.21 was used with the full-information maximum likelihood estimation (Muthén and Muthén 2007), which accommodates missing data by using all available data based on the full sample to estimate each parameter and has been shown to be superior to other missing data methods (Enders and Bandalos 2001). Good-fitting models are traditionally indicated by nonsignificant chi-squares. However, for larger samples, the chi-square ratio (χ^2/df) provides a better assessment by correcting for sample size with its values between 1 and 3 suggesting acceptable fit. Additionally, Root Mean Square Error of Approximation (RMSEA) values below 0.05 and the Comparative Fit Index (CFI) value above 0.90 indicate good model fit (McDonald and Ho 2002).

Results

Unconditional Growth Model of IC

An unconditional model of IC was estimated using both linear and nonlinear functional forms. The chi-square difference test of the linear, χ^2=100.42, *df*=10, and quadratic, χ^2=6.24, *df*= 6, model of maternal ratings of child IC revealed that the quadratic function was a better model for the observed data. Specifically, the chi-square difference value of 94.18 significantly exceeded the criteria value of 18.47 for the difference of 4° of freedom, $p<0.001$, indicating that adding a quadratic term significantly improved the fit. The quadratic model demonstrated excellent model fit, χ^2 (6)=6.24, p=0.40, χ^2/df=1.04, CFI=1.00, RMSEA=0.01. The mean intercept, *B*=0.3.96, *SE*=0.03, $p<0.001$, linear slope, *B*=0.31, *SE*=0.02, $p<0.001$, and quadratic slope, *B*=−0.03, *SE*=0.01, $p<0.001$, were all significantly different from zero. Thus children's IC increased from 2 to 7.5 years of age with a deceleration in growth rate over time as signified by the negative quadratic term. Additionally, the variance of the intercept, *B*=0.38, *SE*=0.04, $p<0.001$, linear slope, *B*=0.10,

SE=0.02, $p<0.001$, and quadratic slope, *B*=−0.001, *SE*=0.001, $p<0.05$, was significantly different from zero, which suggested that children differed in terms of their initial scores of IC and their rates of deceleration in growth over time. The growth factors also significantly covaried with one another. Specifically, the intercept was associated negatively with the linear slope, *B*= −0.07, *SE*=0.03, $p<0.01$, and positively with the quadratic slope, *B*=0.01, *SE*=0.004, $p<0.05$, indicating that higher levels of IC at 2 years were associated with slower growth and more gradual leveling off to age 7.5 years. The linear and quadratic slopes negatively covaried, *B*=−0.01, *SE*=0.003, $p<0.001$, indicating that initially higher levels of positive growth of IC were associated with slower growth later as children aged.

The Intervention Effects on the Growth of IC

A conditional model including intervention status and demographic covariates showed good model fit, χ^2 (22)=44.07, $p<0.05$, χ^2/df=2.00, CFI=0.98, RMSEA=0.04. Residual variance of the quadratic slope was constrained to be zero as it was not significantly different from zero. This procedure also led to improvement in the problem of multicollinearity between the linear and quadratic term. There was a significant effect for the FCU, such that children in the intervention condition demonstrated initially higher levels of growth in maternal ratings of IC from 2 to 7.5 years of age, *d*=0.20, but less pronounced growth, *d*=−0.31, than those in the control condition during the latter stages of the assessment period (Fig. 1).

Indirect Effects on Children's Self-Control

The generalizability of intervention effects on maternal reports of IC to other contexts and informants was tested by including teacher and examiner reports of child self-control at age 7.5 years. The model for teacher ratings of self-control demonstrated good fit, χ^2 (25)=44.92, $p<0.05$, χ^2/df=1.80, CFI=0.98, RMSEA=0.03. As shown in Fig. 1, both the intercept and the linear slope significantly predicted variability in children's self-control, which indicated that children who had higher levels of IC at age 2 years and higher levels of growth over time showed higher levels of self-control at school.

However, the intervention was not directly predictive of teacher ratings of child self-control, suggesting that the effects on self-control at school may be mediated by variations in the early growth of IC. This potential indirect effect was tested using the PRODCLIN program (MacKinnon et al. 2007), which calculates asymmetric confidence limits of the mediated effect based on the distribution of the product of the two random variables. Compared to other methods that assume a normal distribution of the mediated effects, the asymmetric confidence interval method tends to yield more accurate estimates because it takes into account the non-normal distribution of the mediated effects (e.g., MacKinnon 2008). The indirect effect of the FCU on teacher-reported child self-control through variability in linear growth of child IC was significant with lower and upper 95 % confidence limits of 0.14 and 2.10, respectively, consistent with an indirect effect.

As a next step, the model was estimated using examiner ratings of child self-control to corroborate findings using teacher data. This model also demonstrated good fit, χ^2 (25)=47.41, $p<0.05$, χ^2/df=1.90, CFI=0.98, RMSEA= 0.04. Consistent with the model for teacher reports of self-control, both the intercept, *B*=0.44, *SE*=0.15, $p<0.01$, and the linear

slope, B=5.02, SE=1.32, p<0.001, predicted observed self-control at 7.5 years, indicating that children who had higher levels of IC at age 2 years and higher levels of growth over time showed higher levels of self-control during testing. Again, the intervention was not directly associated with examiner ratings of child self-control. However, the indirect effect of the FCU on observed self-control through linear growth in IC was significant with lower and upper 95 % confidence limits of 0.06 and 0.74, respectively.

Indirect Effects on Children's Oppositional Defiant Behavior

Finally, children's oppositional defiant behavior at school was added to the conditional model as a distal outcome, controlling for their earlier levels of oppositional defiant behavior as reported by mothers. This model demonstrated good fit, χ^2 (29)=66.47, p<0.05, χ^2/df=2.29, CFI=0.97, RMSEA=0.04. As presented in Fig. 2, both the intercept and the linear slope significantly predicted variations in teacher ratings of oppositional defiant behavior at 7.5 years, indicating that children who had lower levels of IC at age 2 and less growth over time showed more behavior problems at school after accounting for demographic factors as well as earlier levels of oppositional behavior.

Furthermore, consistent with previous findings using the current sample (Dishion et al. 2014), the FCU intervention predicted teacher reports of children's oppositional defiant behavior at age 7.5 years, B=−0.69, SE=0.30, p<0.05. However, the intervention was not directly related to oppositional defiant behavior when the growth in child IC was included in the model, suggesting that the effects on school-based behavior may be mediated by variations in the early growth of IC. The indirect effect of the FCU on child oppositional behavior through variability in linear growth of child IC was significant with lower and upper 95 % confidence limits of −1.26 and −0.08, respectively, consistent with a mediated effect.

Discussion

The goals of this study were to examine the growth of children's inhibitory control from toddlerhood to early school-age, to investigate the potential effects of the Family Check-Up on its development, and to explore whether the growth of IC based on parental reports would mediate the effects of the FCU on school outcomes within a sample of low-income children. The results indicated that, as hypothesized, maternal reports of child IC followed a positive and nonlinear trajectory from ages 2 to 7.5 years with its rate of growth decreasing over time. Moreover, the FCU promoted IC, such that children in the intervention condition demonstrated more increases in IC than those in the control condition. Finally, by facilitating the growth in IC, the FCU had indirect effects on teacher and/or examiner ratings of child self-control and oppositional defiant behavior at 7.5 years, suggesting that the program's effects may transfer across context, informant, and outcome. The findings were still evident after accounting for variability in demographic qualities as well as earlier levels of oppositional defiant behavior.

Early Development of Inhibitory Control

This study contributed to the field by tracing the developmental course of IC from early to middle childhood during which children make significant improvements in their basic regulatory abilities, including IC, that serve as the foundation for more complex self-regulation skills (Posner and Rothbart 2000). With a total of five assessments of IC, it was possible to test both linear and nonlinear functions to better understand the pattern of change in IC. The results revealed that the child's capacity to suppress inappropriate behavioral responses develops rapidly in the preschool period followed by a gradual leveling off as children reach school-age. The current study confirms and expands prior findings using data from three or fewer points in time (e.g., Li-Grining 2007; Raikes et al. 2007), and provides further evidence that the early childhood period is crucial for children's emerging self-regulation.

Early Family Intervention and Inhibitory Control

As deficits in early self-regulation have been highlighted as a risk factor for a range of negative child outcomes (e.g., Rimm-Kaufman et al. 2009), it would be valuable to investigate whether self-regulation can be promoted as a result of preventive efforts. Much of what is known about the modifiability of self-regulation comes from studies on school-based programs (e.g., Bierman et al. 2008; Raver et al. 2011), and relatively little is documented about such effects before school entry, a gap in the literature that we aimed to address in this study.

Our results indicated that, based on maternal reports, children in the intervention group showed higher increases in their IC ability compared to those in the control group. However, the FCU was not significantly associated with IC scores at any individual time point. Although such contrast may underscore the importance of tracking within individual changes over time, it may also suggest that the effects of the FCU on children's self-regulation were quite modest. Indeed, the effect size was in the modest range, which is comparable to that reported in a meta-analysis of other intervention studies addressing related child attributes (e.g., prosocial behavior; Menting et al. 2013). Nevertheless, the findings, if replicated, may provide useful information for early identification and prevention. Additionally, this study extends an earlier study that found support for the effects of the FCU on promoting child IC between ages 3 and 4 years (Lunkenheimer et al. 2008). The findings also expand previous research that found the FCU to be associated with reduced conduct and emotional problems in childhood (Dishion et al. 2008; Shaw et al. 2009), improved language skills (Lunkenheimer et al. 2008), and positive changes in parenting (Dishion et al. 2008) and parental well-being (Shaw et al. 2009).

An unexpected finding is that children in the intervention condition demonstrated a more pronounced deceleration in IC growth compared to those in the control condition. The result may be due to a ceiling effect as the IC measure we used (CBQ) was developed for children aged 3 to 7. This speculation is also supported by the finding that initially higher levels of positive growth of IC are associated with slower growth later as children moved into the school-age period. Alternatively, this leveling off may reflect a gradual decrease in the FCU's effects on self-regulation, a program that did not directly involve children or target

their regulatory skills. It is noteworthy that the effects of the FCU on IC were unanticipated, because the FCU was designed to promote family management as it applied to problem behavior in childhood and adolescence (Dishion and Stormshak 2007). From these data and the effects we observed, it does seem that family-centered interventions show promise for addressing basic developmental processes like self-regulation. Future research would benefit to consider how the FCU can be improved to have larger and continued effects on this critical dimension of young children's development and adaptation, perhaps by more directly involving the child in the intervention.

The significant effects of the FCU on child IC may be the result of changes in parents' behavior towards children. Positive and effective parenting has been shown to facilitate the development of children's self-regulation abilities (e.g., Bernier et al. 2010). Parents who are responsive, involved, and proactive may help children acquire regulatory skills by anticipating children's needs before they become overly aroused and providing developmentally-appropriate structure to assist children to meet contextual expectations. These parenting strategies likely facilitate children learning self-regulation skills. These parents may also model self-regulation by engaging in planned behavior even in stressful situations such as dealing with their child's misbehavior (Forman and Kochanska 2001). Indeed, in both our FCU trials, as well as in other early parenting intervention trials (Dishion et al. 2008; Gardner et al. 2007), parents were found to increase their use of proactive parenting as a result of the intervention, which in turn has been shown to predict preschoolers' lower levels of disruptive behavior (Dishion et al. 2008) and higher levels of school readiness (Lunkenheimer et al. 2008). Based on these findings, it is speculated that a similar mechanism may intervene the relation between the FCU and child IC demonstrated in this study.

Transferability to the School Context

The ability to prohibit impulsive reactions enables children to initiate alternative behaviors to better negotiate the school context that may be more challenging than the home context (e.g., limited resources, complex peer relationships). Accordingly, a number of school-based programs have targeted children's self-regulation as a vehicle to promote their school adjustment (e.g., Raver et al. 2011). However, this study is one of the few to investigate whether the effects of a home-based intervention on self-regulation generalized to the school context.

The results suggested that a family-centered prevention for at risk toddlers may promote their school behavior by facilitating the early development of IC. The fact that the effects of the FCU could be noticed by teachers who were not aware of children's intervention status provides further support for the effects of the FCU on child IC. The findings are in concert with studies that have shown that classroom-based programs may improve children's school functioning indirectly through their effects on children's self-regulation capacities (Bierman et al. 2008; Raver et al. 2011). This study also expands previous research on the effects of the FCU on self-regulation as a mediator of school adjustment in early adolescence (Stormshak et al. 2010).

It is also noteworthy that in addition to the rate of growth in IC from 2 to 7.5 years, children's IC scores at age 2 (i.e., prior to intervention) predicted their self-control and oppositional defiant behavior at school. This suggests that while the growth of IC may be promoted in a family intervention, initial variations in children's IC may still remain and affect their school adjustment. Such variability in early IC may be reflective of children's temperamental characteristics and/or their interactions with the environment before toddlerhood. Regardless, the finding suggests that early IC may be a useful screener for future adjustment.

Unexpectedly, parental reports of children's oppositional defiant behavior at age 2 were not predictive of teacher ratings of oppositional defiant behavior at age 7.5. This may be due to the developmental nature of the toddler period. Although toddlerhood marks an important period for emerging self-regulation, toddlers frequently display defiant, aggressive, and noncompliant behavior because of their limited cognitive and regulatory skills (Campbell et al. 2000). As many children follow a normative decline in such behavior as they get older, oppositional defiant behavior in toddlerhood may not be a stable predictor of later behavior problems. Indeed, prior studies have highlighted family risk factors (e.g., maternal depression, rejecting parenting) as more consistent predictors of future problem behavior than child risk factors in toddler-hood (Shaw et al. 2000; Shaw et al. 2001). The present findings suggest that poor self-regulation in the toddler period may be an important child risk factor for school-age problem behavior.

Limitations, Future Directions, and Conclusion

This study has a few limitations to note. First, the participants consisted of predominantly European American and African American children of low-income families. Therefore, the extent to which the findings would generalize to children from different racial/ethnic backgrounds or higher income households might be limited. Relatedly, parents with lower levels of education were less likely to participate in follow-up assessments. Thus, the generalizability of our findings may be questioned. However, we attempted to address this potential problem statistically by including parental education as a covariate in all models and using the full-information maximum likelihood method which has been shown to minimize biased estimation in the presence of missing data (Enders and Bandalos 2001). Second, the evaluation of children's IC relied on a single informant. Although maternal reports of IC was further validated by its significant associations with lab measures of IC at ages 3 and 5 years, and by the use of teacher and examiner ratings of child self-control and oppositional defiant behavior as outcomes, it would be beneficial to incorporate more comprehensive assessments of IC to confirm the present findings. Third, because of issues in gaining cooperation from school districts, more than half of the sample did not have teacher reports, thus the findings involving school data should be taken cautiously. Nevertheless, including teacher ratings of child behavior in this study provided an opportunity to explore whether the early intervention effects on IC transferred to a different context and outcome which has rarely been tested in previous studies. We also attempted to partly address the limitation of teacher data by incorporating examiner ratings of child self-control which were not limited in size or disproportionately affected by project site. However, the findings regarding teacher data should be replicated because examiner ratings do not compensate for

the relatively low percentage of teacher ratings, as examiners and teachers observed child behavior in different contexts (i.e., testing session vs. classroom). Finally, this study did not include a valid placebo condition as families in the control group did not have any interaction with the study staff beyond the initial assessment. Adding a better comparison condition (e.g., contact with a parent consultant for a similar length of time as was received by the intervention group) could provide additional information on the effectiveness of the FCU that may foster child IC and related positive outcomes.

Despite the limitations, this is the first known study to examine latent growth in inhibitory control spanning toddler-hood through early school-age and to investigate the effects of a family-centered prevention on promoting children's emerging self-regulation and disruptive behavior during this period. The findings suggest that improving parenting practices may be a promising means to facilitate children's early development of self-regulation, which serves as a foundation for positive functioning in other domains and contexts.

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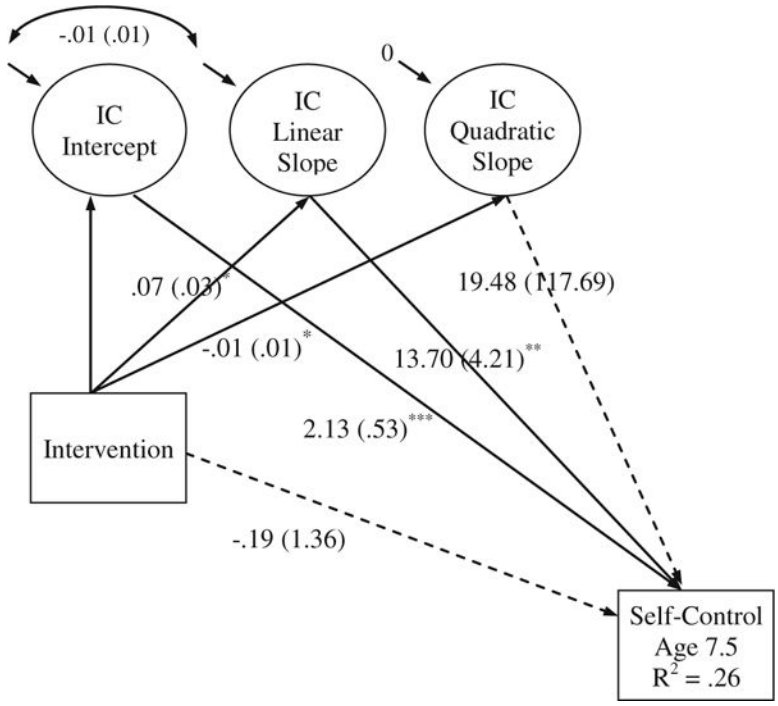

Fig. 1.

Growth in IC as a mediator of intervention effects on self-control at school. *Note*. Unstandardized estimates (standard errors) are presented. Solid lines represent significant paths. IC = Inhibitory control; for intervention group, 1 = *intervention*, 0 = *control*. **p*<0.05, ***p*<0.01, ****p*<0.001

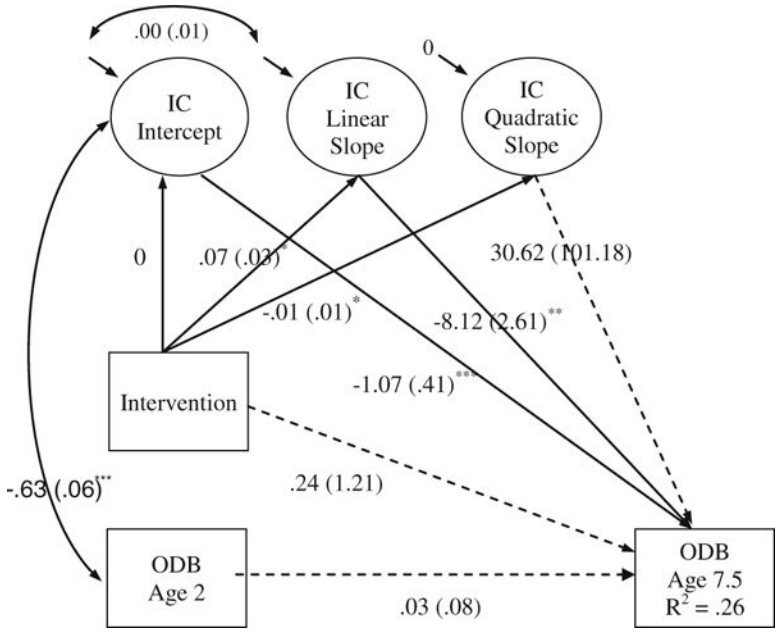

Fig. 2.

Growth in IC as a mediator of intervention effects on oppositional defiant behavior at school. *Note*. Unstandardized estimates (standard errors) are presented. Solid lines represent significant paths. IC = Inhibitory control; ODB = Oppositional defiant behavior; for intervention group, 1 = *intervention*, 0 = *control*. **p*<0.05, ***p*<0.01, ****p*<0.001

Table 1

Descriptive statistics and correlations

Variable		*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12
1.	Intervention group	–	–	–											
2.	Child gender	–	–	0.00	–										
3.	Child race/ethnicity	–	–	0.00	−0.04	–									
4.	Parental education	5.19	1.14	0.01	−0.03	−0.14**	–								
5.	Inhibitory control (M), age 2	3.97	0.80	−0.01	0.12**	0.10**	0.02	–							
6.	Inhibitory control (M), age 3	4.24	0.78	0.05	0.14**	0.02	0.13**	0.51**	–						
7.	Inhibitory control (M), age 4	4.45	0.81	0.06	0.11**	0.02	0.08*	0.40**	0.53**	–					
8.	Inhibitory control (M), age 5	4.67	0.86	0.05	0.16**	−0.01	0.02	0.38**	0.54**	0.62**	–				
9.	Inhibitory control (M), age 7.5	4.86	0.91	0.04	0.14**	−0.01	0.05	0.34**	0.52**	0.52**	0.58**	–			
10.	Self-control (T), age 7.5	13.89	4.62	0.07	0.25**	−0.04	−0.05	0.17**	0.26**	0.27**	0.28**	0.33**	–		
11.	Self-control (E), age 7.5	7.25	1.63	0.00	0.16**	−0.06	−0.03	0.06	0.16**	0.17**	0.27**	0.24**	0.32**	–	
12.	Oppositional behavior (M), age 2	5.76	2.35	0.03	0.00	−0.05	0.01	−0.40**	−0.35**	−0.26**	−0.28**	−0.18**	−0.14*	0.03	–
13.	Oppositional behavior (T), age 7.5	1.92	2.67	−0.13*	−0.27**	0.08	0.03	−0.16**	−0.22**	−0.31**	−0.35**	−0.30**	0.12*	−0.80**	−0.35**

For intervention group, 1 = *intervention*, 0 = *control;* for child gender, 1 = *female*, 0 = *male;* and for child race/ethnicity, 1 = *minority*, 0 = *nonminority;* (M) = maternal report; (T) = teacher report; (E) = examiner report.

* $p<0.05$,

** $p<0.01$

Table 2

Independent t-tests of child variables for intervention and control groups

Variable	*M (SD)*		*t*	*df*
	Intervention	**Control**		
Inhibitory control (M), age 2	3.96 (0.78)	3.98 (0.82)	0.37	718
Inhibitory control (M), age 3	4.28 (0.78)	4.20 (0.78)	−1.26	656
Inhibitory control (M), age 4	4.50 (0.80)	4.40 (0.82)	−1.56	626
Inhibitory control (M), age 5	4.71 (0.87)	4.62 (0.85)	−1.28	614
Inhibitory control (M), age 7.5	4.89 (0.88)	4.82 (0.94)	−0.89	533
Self-control (T), age 7.5	14.20 (4.37)	13.60 (4.83)	−1.13	301
Self-control (E), age 7.5	7.25 (1.60)	7.25 (1.65)	0.03	524
Oppositional behavior (M), age 2	5.82 (2.36)	5.69 (2.34)	−0.77	728
Oppositional behavior (T), age 7.5	1.48 (2.32)	2.23(2.89)	2.45*	295

(M) = maternal report; (T) = teacher report; (E) = examiner report.

*$p<0.05$