ADVERSITY AND EXECUTIVE FUNCTIONING IN AN URBAN PRESCHOOL SAMPLE

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THESIS ABSTRACT

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This study tested for a relation between risk and child executive function (EF) in an urban preschool sample. I hypothesized there would be a quadratic relation, a negative relation between adversity scores and EF performance at lower levels of adversity, and a positive relation between adversity scores and EF performance at higher levels of adversity. Participants were 39 children ranging in age from three to five years old. Tasks from the NIH Toolbox, Head-Toes-Knees-Shoulders, Forward Digit Span, and a variety of questionnaires on cumulative risk indexed EF and risk, respectively. Pearson correlations and multiple regression analysis tested for relations. Multiple regression analyses controlled for age, sex, and race/ethnicity. Additional post-hoc models further controlled for internalizing factors, externalizing/ADHD factors, and time of day. Age significantly related to EF in all models, but risk did not. The current study did not find support for either a quadratic or positive relation between risk and EF. I discuss both limitations and directions for future research.

Adversity and Executive Functioning in an Urban Preschool Sample

This study tests the relation between risk and executive functioning (EF) in an urban preschool sample. Various adverse experiences and risk factors, used interchangeably here, have been linked to poor developmental outcomes, including EF. Meanwhile, EF has been linked to positive developmental outcomes, even when developmental risk occurs. Findings are mixed with respect to the relation between adversity and EF, with a possible difference for students who experience a moderate level of adversity compared to those with very low or very high levels. I test for a quadratic relation between parent-reported risk and observed child EF among students attending an urban preschool. I expect a generally negative relation between risk and EF at low-to-moderate levels of adversity, and a generally positive relation between adversity and EF at higher levels of adversity.

Executive Functions and Their Importance

Executive functions (EF) refer to top-down mental processes that permit an individual to inhibit an automatic or dominant response in the service of goal-directed behavior (Diamond, 2013). In general, inhibitory control, working memory, and cognitive flexibility comprise the three core elements of EF. Inhibitory control is the ability to inhibit impulses, fight against automatic responses, and resist distracting stimulation to direct attention, behaviors, emotions, and thoughts towards a goal. Working memory is the ability to retain and manipulate information even when no longer perceptually present (Diamond, 2013). Cognitive flexibility is the ability to shift between conceptual frameworks (Zelazo & Bauer, 2013). Cognitive flexibility lets one shift their perspective both spatially and interpersonally. To accomplish this, cognitive flexibility builds upon the previous development of both inhibitory control and working memory (Diamond, 2013).

EF are important on a variety of levels. For example, those lacking in inhibitory control may find themselves at a disadvantage with respect to a variety of outcomes later in development. Moffitt et al. (2011) highlights the predictive ramifications of inhibitory control development later in life by following the same urban cohort into adulthood. Children who had better inhibitory control over the age range of 3 to 11 were more likely to have continued their education into their teens, be law abiding, have better mental and physical health, earn a high living wage, and be less likely to make risky decisions. In preschool, the development of inhibitory control promotes adherence to rules, the facilitation of learning through visual and auditory stimuli, and sitting still (Bierman, Nix, Greenberg, Blair, & Domitrovich, 2008). Inhibitory control plays a significant role in social-emotional competence. Preschoolers with higher inhibitory control scores tended to rate lower on measures of internalizing behavior and higher on social skills (Rhoades, Greenberg, & Domintrovich, 2008).

Both poor working memory and poor cognitive flexibility predict negative outcomes related to scholastic achievement (be it math, reading, or otherwise) later in life. More so than full scale IQ, working memory at the start of education is powerful predictor of academic success (Alloway & Alloway, 2009; Blair & Raver, 2015; Bull & Scerif, 2001; Gathercole & Pickering, 2000; McLean & Hitch, 1999). Additionally, cognitive flexibility is in part responsible for the development of empathy, which, in turn, has implications for social and academic functioning (Diamond, 2013; Izard, Fine, Schultz, Mostow, Ackerman, & Youngstrom, 2001).

Executive Functions Development During Preschool

The development of EF is a rapid process from birth throughout early childhood (Anderson, 2002). In terms of inhibitory control, by the age of 9 months a child will still possess difficulties towards inhibiting previously learned responses yet by 12 months demonstrate greater capacity to inhibit most behaviors and shift between response sets. At age 3 most children show even greater capacity to inhibit automotive behaviors, but still struggle to halt the behavior. Both speed and accuracy in impulse control tasks improve through up to age 6. For cognitive flexibility, 3-year old children have great difficulty with simple conceptual reasoning. Before age 4 they become able to consistently generate new ideas and concepts. Between the age of 3 and 4 the ability to switch between rudimentary response sets begins to develop. Rules that are too complex are still difficult to switch between. Between ages 3 and 5 both response speed and verbal fluency develop incrementally (Anderson, 2002).

Supporting the development of good EF in early life will likely result in better life outcomes. Experiencing psychosocial adversity can interfere with EF development. Psychosocial deprivation may lead to development of indiscriminate behaviors, inattention or overactivity, and difficulty developing adaptive social relationships with adults and peers (Chisholm, 1998; Kreppner, O'connor, Rutter, & English, 2001; Zeanah, Smyke, Koga, Carlson, & Bucharest, 2005). Furthermore, those experiencing poverty are at risk for worse developmental outcomes in terms of language, literacy, and social-emotional maturity compared to their more well-off peers. School performance gaps, worse high school graduation rates, and lower long-term employment potential are more common among children who experience poverty (Bierman et al., 2008).

Assets and other positive factors in children's lives can promote good development of EF. Parent and child relationship quality is related to child EF in preschool (Hammond, Müller, Carpendale, Bibok, & Liebermann-Finestone, 2012). Positive parenting may moderate the relation between EF and adversity, as could other protective factors in the child's life (Fay-Stammbach, 2014). Pertaining to education, studies of the effects public prekindergarten programs on development and the relationship between socioeconomic status and its impact on early childhood EF suggest that the EF of a child enrolled in such programs predicts school readiness beyond socioeconomic status and other cognitive skills (Calvo & Bialystok, 2014; Fitzpatrick, McKinnon, Blair, & Willoughby, 2014; Raver, Blair, & Willoughby, 2013; Weiland & Yoshikawa, 2013).

Resilience and Executive Functions

Resilience in development refers to positive outcomes despite risk or adversity (Luthar, 2015; Masten, 2001). Determining resilience is highly context dependent and inferential. First, resilience requires that the individual be functioning at a competent level, suggested by what their cultural or social context expects of them. Importantly, the individual also needs to have experienced or be experiencing some adversity, a threat to their functioning that, on average, would suggest that they might not be showing competence (Luthar, 2015; Masten, 2001). Many children show resilience by demonstrating good EF despite the experience of adversity. Resilience occurs due to protective and promotive factors that allow for a child to successfully adapt to adversity (Luthar, 2015; Masten, 2001). EF is itself a protective factor for other outcomes, and promotive and protective factors support good development of EF in contexts of adversity

(Blair & Diamond, 2008; Hostinar, Stellern, Schaefer, Carlson, & Gunnar, 2012; Shonkoff, 2011).

Adversity, Importance, and Means of Measurement

Modern studies of risk and adversity in development have spanned nearly 50 years (e.g., see Cutuli, Herbers, Masten, & Reed, in press). These studies often consider whether individuals who experience one or more factor differ from those without that experience on some outcome. A wide variety of factors have been considered, including sociodemographic circumstances (e.g., experiencing poverty; single-parent households), family factors (e.g., harsh parenting), and individual characteristics (early temperamental profiles; see Obradovic, Shaffer, & Masten, 2012). Many sample-based studies aggregate adverse experiences through constructing a cumulative risk index which sums the number of adverse factors present for each participant (Evans, 2003; Evans & English, 2002; Lengua, Honorado, & Bush, 2007; Lengua, Moran, Zalewski, Ruberry, Kiff, & Thompson, 2015; Mistry, Benner, Biesanz, Clark, & Howes, 2010; Roos, Kim, Schnabler, & Fisher, 2016). Cumulative risk approaches reduce specificity but increase power in predicting outcomes given the potential impact of a variety of factors contributing to an indicator of a general level of risk. This approach appears to well-represent the general level of risk and predicts a variety of important developmental outcomes (Evans, 2003; Evans & English, 2002; Lengua et al., 2007; Lengua et al., 2015; Mistry et al., 2010; Roos et al., 2016). Cumulative risk scores are particularly useful given that individual risk factors tend to co-occur and possess a high degree of overlap (Masten, 2001; Roos et al., 2016).

A common cumulative risk approach involves asking about a variety of psychosocial adversities that may have been experienced. Adverse childhood experiences

(ACEs) are key risk factors for negative health outcomes (Wade, Shea, Rubin, & Wood, 2014). ACEs can impact early childhood development or adult outcomes (Duncan, Brooks-Gunn, & Klebanov, 1994; Edwards, Holden, Felitti, & Anda, 2003; Felitti, Anda, Nordenberg, Williamson, Spitz, Edwards, & Marks, 1998; Hillis, Anda, Dube, Felitti, Marchbanks, & Marks, 2004; Leventhal & Brooks-Gunn, 2000; Widom & Kuhns, 1996). Parents that have experienced several ACEs are at increased risk of mental health and substance abuse problems, poor social networking, and decreased educational achievement. These factors combined with economic hardship can make for a poor environment for children to receive the support and nurturing they require for proper development. In effect, the negative experiences of the parent serves to inform the negative experiences of the child and their outcomes (Bridgett, Burt, Edwards, & Deater-Deckard, 2015; Shonkoff, Garner, Siegel, Dobbins, Earls, & McGuinn, 2012).

While ACEs possess a broad application, it is worth considering whether they truly encompass all encounterable forms of adversity in an urban context or if they in turn are rather limiting instead. Wade et al. (2014) sought to determine the kinds of potential adverse childhood experiences found in the urban Philadelphia population. The domains of family relationships, community stressors, personal victimization, economic hardship, peer relationships, discrimination, school, health, child welfare/juvenile justice, and media/technology organized the distinct adverse experiences. Within the confines of these groupings the more traditional ACEs of physical, psychological, sexual, emotional abuse, and physical neglect alongside home substance abuse, criminal activity, mental illness, divorce/separation, and intimate partner violence made prominent showings. Outside the confines of ACEs, the researchers concluded future endeavors into studying ACEs should look to include consideration of single-parent homes, lack of parental love, support, and guidance, death in the family, exposure to violence, “adult themes”, criminal behavior, and economic hardship (witnessing parental financial struggles, lack of resources [i.e. – homelessness], etc.) as worthwhile adverse life experiences to keep in mind (Wade et al., 2014). Overall, to further evaluate risk, perhaps reinforcing the presence of risk through a combination of multiple corroborating measures is worth exploring to generate a more complete picture.

Adversity and Executive Functions

Many different forms of psychosocial risk have been tied to worse developmental outcomes in general, and to lower levels of EF in particular. Common risk factors include measures of socioeconomic status (SES), divorce, low birth weight, and other negative life time events (Masten, 2001; Obradović et al., 2012). These factors have been used in various ways to predict poorer average functioning among groups of children.

EF appears to promote good academic outcomes at least among young children from low SES backgrounds, even after controlling for fluid intelligence and cognitive processing speed (Fitzpatrick et al., 2014). Furthermore, young children who spent greater time over four years in poverty suffered decreased EF compared to their peers exposed to more ideal conditions (Raver et al., 2013). Findings were moderated by the temperament of the child, thus concluding that not all developing individuals experience equally detrimental effects due to their socioeconomic status (Fitzpatrick et al., 2014). More specifically, children who were more temperamentally reactive exhibited lower EF in heightened hardship versus their higher EF growing up with comparatively less socioeconomic stressors (Fitzpatrick et al., 2014).

For 5 to 6-year old children involved with child protective services the effects of cumulative adversity on their EF development has been researched both between-groups and within-groups (Roos et al., 2016). Children involved with child welfare had lower average levels of EF compared to lower-adversity peers. However, there was a positive correlation within the adversity group between higher levels of accumulated adversity and better EF. Other work in the context of poverty has found that family instability (e.g. change in caregiver, fluid household environment, lack of consistent place of residence, etc.) fails to decrease executive control (cool effortful control; motor inhibition, effortful attention, etc.) and rather only negatively influences delay control (hot effortful control; Sturge-Apple, Davies, Cicchetti, Hentges, & Coe, 2017).

For young children (age range four to six) experiencing homeless, a peculiar finding appeared in the research of Herbers, Cutuli, Monn, Narayan, & Masten (2014). They posited that adverse childhood experiences would predict, among other things, worse EF. Previous findings suggested the experience of homelessness and other such adverse conditions without adequate caregiver support lead to poor EF outcomes. They instead found a modest positive relationship between EF and adversity. Herbers et al. (2014) was however quick to call for additional research into examination of factors they failed to consider in the context of their research due to their apparent nature as outliers. Similar to their study from three years prior, Herbers, Cutuli, Kolarova, Albu, & Sparks (2017) also found within a sample of 8 to 11-year-old children staying in family housing that there was a positive relation between EF and each of the traumatic stress symptom scores and depression symptom scores. Overall, the relation between adversity and EF appears to differ as a function of the overall adversity level. Studies utilizing more general samples of children tend to find the negative association between adversity and EF. However, studies utilizing high-adversity samples have found the positive association between incremental adversity levels and EF. In particular, the "shift-and-persist" model exists to serves as further basis to support this notion. Though the reason for their positive outcomes stems from the child being able to find appropriate role models while they are facing adverse situations, the fact that these positive outcomes occur at all lends support to the idea it is worth considering positive outcomes despite adversity in other contexts (Chen & Miller, 2012). Thus, this suggests a parabolic relation among samples that contain sizeable numbers of children who experience low or high levels of adversity.

Current Study

The current study tests for a relation between risk and EF among three-to-five-year old children attending an urban preschool program. Consistent with past studies, I hypothesized a quadratic relation such that students in this general sample would show a negative relation between adversity scores and EF performance at lower levels of adversity. At higher levels of adversity, I expected a positive relation between adversity scores and EF performance.

Methods

Child participants completed assessments using an iPad with the NIH Toolbox App (Dimensional Change Card Sort, Picture Vocabulary Test, and Flanker) and Research Assistant administered tasks (Forward Digit Span and Head-Toes-Knees-Shoulders). Parent/Guardian(s) filled out paper-and-pencil assessments. Analyses involved evaluation of the reported negative life events for both the parent and child and a cumulative risk score derived from parent interview questions all in relation to evaluated EF skills.

Participants

All families with a 3-5-year-old attending a specific summer preschool program in Camden City were eligible to participate. Parents/guardians provided informed consent and completed questionnaires available in Spanish or English. Children (N = 39) completed assessments in English during their program day. The children were exclusively from minority racial/ethnic backgrounds, including African American (n = 23; 58.97%) and Non-African American (n = 16; 41.03%). The sample had 15 (38.46%) girls and 24 (61.54%) boys.

Measures

Demographic information. I obtained child demographic information from preschool records and from parent report.

Executive functioning. Data came from four standardized assessments of EF: (1) The NIH Toolbox's Flanker task, (2) the Dimensional Change Card Sort with developmental extension of the NIH Toolbox, (3) Forward Digit Span, and (4) Head-Shoulders-Knees-Toes. I constructed a single composite of EF based on standardized (z-transformed) scores if scores demonstrated good reliability via Cronbach's alpha.

NIH Toolbox Flanker Inhibitory Control and Attention Test (Flanker). The Flanker tests participant capacity to inhibit visual attention to irrelevant task dimensions. For each trial a target at the center of the iPad's screen was accompanied by similar stimuli on its right and left (2 on its left and right respectively). The participant's goal was to determine the direction of stimulus at the center of the screen. The test could be comprised of rounds where both the center stimulus and flanking stimulus all face the same direction (congruent) and trials where the center stimulus and flanking stimulus face the opposite direction from one another (incongruent). Accuracy and reaction time were combined via scoring algorithm to generate a score ranging from 0 to 10 (Gershon, Wagster, Hendrie, Fox, Cook, & Nowinski, 2013). Test-retest reliability was found to be at $\alpha = .96$ for all ages combined and at $\alpha = .95$ for ages 3 to 15 years old (Weintraub et al., 2013).

NIH Toolbox Dimensional Change Card Sort (DCCS). The target visual stimulus (a color or shape) must be matched to 1 of the 2 choice stimuli. Participants completed a set of trials that had a composition dependent on how well they performed in the task. The variations on how the trials played out vary from matching color to color, shape to shape, a combination of the tasks, and a variation on all three tasks where the participants were matching opposites. "Color" or "shape" were voiced by the computer before the participant was tasked to choose the appropriate stimulus for the task dependent on the trial's directions. Accuracy and reaction time were combined via scoring algorithm to generate a score ranging from 0 to 10 (Gershon et al., 2013). Test-retest reliability was found to be at $\alpha = .94$ for all ages combined and at $\alpha = .92$ for ages 3 to 15 years old (Weintraub et al., 2013).

***Forward Digit Span*.** The assessment was a battery of two-part number sequences. For each part of the measure, the participant listened to the research assistant read the number sequence off the page (starting with the first part of the battery being two numbers long, increasing one in number for each subsequent part until becoming nine numbers long for part eight) then had them repeat what you read to them and recorded their response. If the participant repeated incorrectly, they repeated the process for the second part of the number sequence. Testing continued until either the participant repeated two number sequences of the same length incorrectly or they manage to make it all the way through to the end. No feedback was to be offered for the duration of the game. Test-retest reliability was found to be on the subscales at α = .69 - .81 (Petermann, & Petermann, 2011; Ponitz, McClelland, Jewkes, Connor, Farris, & Morrison, 2008).

***Head-Toes Knees-Shoulders (HTKS)*.** The participant was tasked with mimicking the research assistant’s actions and doing the opposite of them. The assessment began with a six-part practice where they were standing three feet away and facing the seated research assistant. The research assistant would carefully relay the directions and both state the action the participant should take (either head or toes) and demonstrated it themselves. If the participant failed to correctly mimic and follow the research assistant’s directions, the research assistant was to retrain them up to three times upon subsequent errors before no longer giving feedback. Completion of the practice lead to the ten-part test where the participant did the opposite action of what the research assistant dictates. No feedback was to be given nor was the participant to move onto part two unless they demonstrated five or fewer mistakes. Part two was a new set of commands (knees and shoulders) for the practice round and a combination of all four introduced commands (head, toes, knees, and shoulders) for the actual testing portion. Both practice and test were to be done with the participant responding to the research assistant's prompts in the opposite of what they command. The test possessed an inter-rater reliability of $\alpha = .95$ for self-correct responses and $\alpha = .98$ overall. Construct validity was measured in terms of age's effects on performance and was found to be $p<0.01$ at $F(8, 1320)$ (Ponitz et al., 2008).

Risk. Three measures of risk informed a single indicator encompassing negative life events experienced by the parent, negative life events experienced by the child, and sociodemographic and birth risks. I took a traditional cumulative risk approach and summed the number of risks present for each child (e.g., sum of life events and other discrete risks).

Parent Life Time Events Questionnaire (PLTE). The PLTE was a 23-item questionnaire pertaining to specific adverse life events the child's parent may have experienced in their life time. Parents were tasked to answer yes or no to whether they experienced a given event. If the answer was yes, the parent was to additionally offer whether they experienced the adverse life event before, after, or for both before and after age 18. A cumulative risk index score was derived as a sum of all the endorsed items in the questionnaire (Masten, Neemann, & Andenas, 1994).

Child Life Time Events Questionnaire (ChLTE). The ChLTE was a 22-item questionnaire pertaining to specific adverse life events the child may have experienced. Parents were tasked to answer yes or no to whether the child may have experienced a given event. If the answer was yes, the parent was to additionally offer at what age the child had that particular life experience. A cumulative risk index score was derived as a sum of all the endorsed items in the questionnaire (Masten, Neemann, & Andenas, 1994).

Cumulative Risk Composite (CRC). A 0 to 6 scale composite measure of risk derived from a sampling of Parent Interview Questions pertaining to Parental Education, Parental Unemployment, Maternal Age at Child Birth, Preterm Birth, and Low Birth Weight. Each applicable question was assigned a value of 0 or 1, with multiple questions pertaining to the same risk only counting once towards the score. Each question was assigned a value of one when the answer met the defined criteria. Less than High School Education, Lack of Current Employment, 3 or more places of residence, a preterm birth of 4 or more weeks early, weighing less than 5 pounds 8 ounces, and being younger than 18 at the time of child birth were all defined criteria to be met for each respective risk category. While not all items have necessarily been employed to develop the exact same cumulative risk score in previous derivatives, chunks of them have been employed in the same summed score (Evans 2003; Evans, Kim, Ting, Tesher, & Shanis, 2007; Liu, Hanlon, Zhao, Cao, & Compher, 2014; Velders et al., 2011).

Variables for post-hoc analyses. Three additional control variables were considered in the form of Internalizing and Externalizing/ADHD factors and Time of Day.

Internalizing Factors. Composed of a mean of two subscales for depression and overanxious. The depression subscale is the mean of six items that ask about sad mood and depression-related symptoms. The overanxious subscale is the mean of eight items that ask about worries, complaints, and self-consciousness related anxiety symptoms. The internal consistency of the scale in a previous psychometric study was $\alpha = .69$ overall and the individual subscales of depression and overanxious had α of .77 and .76, respectively (Armstrong, Goldstein, & The MacArthur Working Group on Outcome Assessment, 2003).

Externalizing/ADHD Factors. Composed of a mean of six subscales for oppositional defiant, conduct problems, overt hostility, relational aggression, inattention, and impulsivity. The oppositional defiant subscale is the mean of 9 items asking about their temper, aggressive behaviors, and other oppositional defiant symptoms. The conduct problems subscale is the mean of 11 items asking about subversive behaviors, anti-social behaviors, and other conduct problem symptoms. The overt hostility subscale is the mean of 4 items asking about the forms of hostility they exhibit. The relational aggression subscale is the mean of 6 items asking about specific aggressive behaviors they exhibit. The relational inattention subscale is the mean of 6 items asking about their ability to handle distraction and concentration. The impulsivity subscale is the mean of 9 items asking about their behaviors related to self-control. Furthermore, no subscale can be missing in order to calculate the scale score. Past psychometric research found the internal consistency of the scale was $\alpha = .85$ overall and the individual subscales of oppositional defiant, conduct problems, overt hostility, relational aggression, inattention, and impulsivity had α of .85, .72, .77, .88, .90, and .91 respectively (Armstrong et al., 2003).

Time of Day. Collected directly from the iPad recorded start time of the DCCS and subsequently converted into minutes (e.g., 0 representing midnight, 720 representing noon, etc.).

Data Analysis

I tested the study hypothesis using multiple regression. Preliminary analyses involved inspecting the data for the apparent nature of the relation between adversity and EF. I hypothesized that there would be a polynomial (quadratic) pattern evident in the scatterplot. If so, I would model the composite EF score as a quadratic dependent variable predicted by the composite adversity score, controlling for child age, sex, and race/ethnicity. If no quadratic pattern was evident in the scatterplot, I would model the relation between adversity and EF as linear, controlling for child age, sex, and race/ethnicity.

Results

Results are presented in three parts. I present descriptive statistics for the risk scores and correlations between study variables, test of the hypothesis, and several post hoc analyses.

Descriptive statistics for risk scores.

Risk scores were the combination of three measures and scatterplot graphs of the relation between risk and EF suggest a linear association. Parents reported on both their own adverse life events and risks for their children. The mean combined risk score was 5.56 (SD=3.30, range=1-13). For the individual measures, the mean scores for the ChLTE, PLTE, and CRC were 1.21 (SD=1.49, range=0-6), 3.97 (SD=2.77, range=0-12), and 0.54 (SD=0.60, range=0-2), respectively. Numbers and percentages for all reported risk measures are presented in Tables 1 to 3. Scatterplot analysis (see Figure 1 in the appendix) was done between the cumulative risk score and the child's composite executive function score. As no quadratic pattern was observed evident in the scatterplot; The appropriate model for regression was linear.

I tested for relations between risk scores (continuous), executive function scores (continuous), age (continuous), sex (female = 0; male = 1), and race/ethnicity (not African American = 0; African American = 1) using Pearson correlations. Only age ($r = .55$; $p < 0.001$) and sex ($r = -.34$; $p < 0.05$) were significantly related to EF. Child age was significantly related to risk scores ($r = .38$; $p < 0.01$). See Table 4.

Hypothesis test.

Linear regression tested the relation between risk and EF, controlling for child age, sex, and race/ethnicity. There was no such relation (B = -0.00; StdError B = 0.13). See Table 5.

Post hoc analyses.

Post hoc analyses considered additional control variables in the linear regression model. This included child mental health (internalizing and externalizing/ADHD behaviors) and the time of day each child completed the EF assessment. I completed additional analyses considering all main effect combinations for these variables and risk, controlling for age, sex, and race/ethnicity in each. None of the post-hoc control variables demonstrated any significant relation with child EF in any model, nor did the relations between risk and EF meaningfully change (See Table 6).

Further post hoc models tested for effects of risk on two individual components of the EF score: on DCCS score as a representation of cognitive flexibility and on Flanker score as a representation of inhibitory control. These models mirror the main effect models described above and controlled for age, sex, and race/ethnicity. There was no significant relation found between risk and the EF components. See Tables 7 and 8.

Discussion

There was no relation between risk and child EF. The current study tested such a relation among three-to-five-year old children attending an urban preschool program. I hypothesized a quadratic relation such that the students would show a negative relation between risk scores and EF performance at lower levels of risk. At higher levels of risk, I expected a positive relation between risk scores and EF performance. First, scatterplot graphs of the relation between risk and EF suggested a linear association and not a quadratic one. When controlling for age, sex, and race/ethnicity, there was no significant relation between risk scores and child EF scores. Only age significantly predicted child EF scores.

The current findings contrast with previous findings on the relation between adversity and EF. For example, the positive association between risk and EF in Roos et al. (2016) may have eluded the current study because of several methodological differences. First, Roos et al. (2016) reported a significant-but-small correlation ($r = 0.12$) between cumulative risk and child performance on a flanker task at ages 3 through 6. If a positive relation exists in this urban preschool population, perhaps it is a matter of the effect being so small that observing it in the current, small sample would be unlikely. Roos et al. (2016) was better-powered to detect such small effects ($N=392$ for passing Flanker task performance in Roos et al., compared to a total of $N=39$ for complete data in the current sample).

Further consideration should be given towards the context in which Roos et al. (2016) and Herbers et al. (2017) observed their positive effects of risk on EF. In contrast to my own study, Roos et al. (2016) observed relations between EF and risk that occurred later, around the ages of 8 to 10 years old (roughly 3 to 5 years after the study began). Earlier-experienced risk, around the ages of 5 to 6.5 years of age, did not relate to EF. My sample was entirely comprised of children 3 to 5 years old. The hypothesized effects might only manifest later in childhood. Related, the Herbers et al. (2017) sample was also composed of considerably older children than in the current study. However, Herbers et al. (2014) used a sample of preschoolers and still observed a positive risk-EF relation. Overall, I failed to find the hypothesized effects with this preschool sample. Future research should consider developmental changes and age-related processes in the formation of risk-EF relations.

Another consideration relates to the relative level of risk and degree of adverse experiences in the current sample relative to past studies that find a positive relation between risk and EF. The most common risk factors in the current study were for divorce or permanent separation of their parents (10 out of 39 answered affirmative), an incarcerated parent (9 out of 39 answered affirmative) and having previously been hospitalized (9 out of 39 answered affirmative). These most-common experiences contrast with the risk groups considered in past work, including maltreated children (Roos et al., 2016) and children in homeless shelters (Herbers et al., 2014, 2017).

I added a series of post-hoc analyses to test for potential contributions or confounding effects of child mental health and the session time of day. Associations between antisocial behavior and EF impairment have been observed in adolescent and adult populations (Morgan & Lilienfeld, 2000; Ogilvie, Stewart, Chan, & Shum, 2011). Additionally, this finding had been corroborated among a population of 7 to 12-year-old children. Children who struggle with hot EF tasks in middle childhood are at risk for externalizing behavioral problems (Woltering, Lishak, Hodgson, Granic, & Zelazo, 2015). Furthermore, in a preschool population, those exhibiting heightened negative emotionality in conjunction with low inhibitory control exhibit higher levels of aggression (Suurland, Van der Heijden, Huijbregts, Smaling, De Sonneville, Van Goozen, & Swaab, 2016). Time of day, being an indicator whether the participants have eaten, is being considered for purposes considering hunger and its relation to EF. On the extreme end of the scale, a number of studies link reduced self-control to hunger (Gailliot, 2012). Despite these considerations, there were no significant relations between any of these variables and EF in any of the new models. While both mental health and the session time of day might be important for EF in other contexts, the current findings do not corroborate an association.

I also completed two more series of models as post-hoc analyses. These evaluated effects of risk on individual components of EF, namely set shifting (DCCS score) and inhibitory control (Flanker). I reran all models with these scores as the dependent variables. These models help rule out the possibility that the hypothesized effects occurred as a specific feature of discreet EF components, given that past studies used different methodologies and measured different components of EF. For example, Mittal, Griskevicius, Simpson, Sung, and Young (2015) had the overall goal of determining whether growing up in a stressful childhood environment enhanced certain cognitive functions. To that aim, they employed a pair of executive function tasks measuring for inhibitory control and shifting (cognitive flexibility). In experiencing a childhood in which the environmental conditions surrounding them fluctuates in harshness, those that performed worse at inhibition found themselves performing better when it came to set shifting. It was only in situations of uncertainty that the differences between performance in unpredictable and predictable childhoods were observed. Set shifting may be useful in unpredictable environments. When parsed, I wanted to test whether performance on the individual measures of the DCCS and the Flanker in the current study replicate the findings of the Mittal et al. (2015) study. They do not.

Other key studies deployed different approaches to measuring EF or individual components. Herbers et al. (2014) employed measures indexing set shifting and inhibitory control, Herbers et al. (2017) employed measures for set shifting alone, and Roos et al. (2016) utilized a color Flanker. The current study found a modest bivariate effect between the DCCS and risk when run as a Pearson correlation, but when run with covariates in a linear regression model the effect was non-significant. The Flanker was not related to risk. These findings fail to replicate the cited work, though differences in sample and power to detect effects must continue to be noted. Furthermore, Mittal et al. (2015) indexed risk through retrospective recall, and the sample had been, on average, 22.8 years old.

This current study had a number of other limitations. Missing data presents a possible source of bias. Out of a total consented participant pool of 93 individual children, 82 were ultimately able to complete a child session and only 62 families handed back the survey detailing cumulative risk. Whittling it down further, only 39 have a complete set of data being used in evaluation of the current hypothesis and models.

The study would have benefited from a prospective, longitudinal design to detect growth in EF and the prospective impact of risk experiences. The study lacks a baseline assessment of EF before the participants entered the preschool program for sake of comparison and later progress during the year. While the need to control for child age would still be required on account that children can begin preschool at varying, there would be greater assurance in growth if I could compare multiple time points of data as opposed to relying on a single assessment. Both consistent data gathering and a larger span of time need to pass in order to increase the number of time points I have to draw from and analyze. A further limitation is my inability to run child sessions with non-English speaking children. The program planned to collect data with Spanish speaking children, but additional challenges emerged.

Finally, the relation between risk and EF may only occur at extremely high levels of risk, beyond what was encountered in the current sample. As also touched upon with Mittal et al. (2015) study, it is worth considering the idea that my sample may perhaps not be representative of high risk. The parents' reported a high amount of risk in their own lives, on average. Intergenerational transmission of risk is a negative indicator of child development (Bridgett et al., 2012). However, the parents reported comparatively few risks experienced directly by the child. The children's first-hand experienced risk might be a better predictor of their EF status. Future research may wish to innovate other ways to index the risks directly experienced by the child. The low levels of child-experienced risk may contribute to the lack of an effect of risk on EF. My sample might be comparatively lower in risk because of the young age of the children. A longitudinal design would allow me to index whether and how risk factors accumulate over time. Further, I must always be aware of social desirability and the potential of felt-stigma when attempting to measure risk. The ever-present phantom of self-reporting biases may also haunt the current study. Parents may be unwilling to completely divulge the extent of children's experiences of risk, despite assurances of confidentiality, as the subject is sensitive.

My hypothesis failed to find support. Age had a significant relation with the child's composite EF scores across all models. This is consistent with previous research and supports the validity of the EF measures which are well known to vary with age (Anderson, 2002; Best & Miller, 2010). However, no other variables were significance significantly related to EF in my multiple regression analyses. Future research would consider why I found no relation between risk and EF. Longitudinal work should establish a baseline for risk and EF. Regular follow-up assessments of risk and EF would allow me to test whether changes in risk experiences coincide with differences in growth in EF over time. Assessments could occur every six months because EF development is rapid during this age range. Additional attention to the measurement of child-experienced risk is also warranted so as to minimize social desirability and concerns about stigma. The current study did not find support for either a quadratic or positive relation between risk and EF, despite past findings with high-risk groups suggesting one of these would be the case (Herbers et al., 2014; Herbers et al., 2017; Sturge-Apple et al., 2017).There was no relation to EF, despite other literature that suggests a negative relation between risk and EF (Masten, 2001; Obradović, Shaffer, & Masten, 2012; Raver et al., 2013). While there are methodological issues that need to be addressed in future research, the current findings do not support the stance that risk contributes to differences in EF.

Tables and Graphs

Question	n	answered yes	answered no	missing	% answered total (out of N = 93)	% answered yes (out of 'n')	% answered no (out of 'n')
Experienced the death of a parent	39	1	38	54	41.94%	2.60%	97.40%
Experienced the death of a brother or sister	39	1	38	54	41.94%	2.60%	97.40%
Lived in a home with fights or severe relationship problems between parents and adults taking care of him/her	39	4	35	54	41.94%	10.26%	90.74%
Experienced the divorce or permanent separation of his/her parents	39	10	29	54	41.94%	25.64%	74.36%
Lived with a parent who had a serious alcohol or drug problem	39	0	39	54	41.94%	0.00%	100%
Lived with a parent who had a mental illness	39	2	37	54	41.94%	5.13%	94.87%
Lived with a parent who had a serious physical illness	39	0	39	54	41.94%	0.00%	100.00%
Had a parent who was in prison	39	9	30	54	41.94%	23.08%	76.92%
Lived in a foster home	39	0	39	54	41.94%	0.00%	100%
Been separated from his/her parents for more than 2 weeks	39	7	32	54	41.94%	17.90%	82.10%
Been hospitalized	39	9	30	54	41.94%	23.08%	76.92%
Been the victim of physical violence (for example, your child was seriously injured by another person)	39	1	38	54	41.94%	2.60%	97.40%
Seen a parent injured by another person	39	1	38	54	41.94%	2.60%	97.40%
Seen violence happening to other people	39	1	38	54	41.94%	2.60%	97.40%
Been in a serious accident, (car, bike, boat), or nearly drowned	39	1	38	54	41.94%	2.60%	97.40%
Witnessed a serious accident involving a car, plane, or boat	39	0	39	54	41.94%	0.00%	98.40%
Experienced a natural disaster such as a flood, hurricane, or tornad	39	0	39	54	41.94%	0.00%	98.40%
Been in a house fire	39	0	39	54	41.94%	0.00%	98.40%
Been attacked by an animal	39	0	39	54	41.94%	0.00%	98.40%
Been kidnapped	39	0	39	54	41.94%	0.00%	98.40%
Experienced any other severe threat to his/her life or safety	39	0	39	54	41.94%	0.00%	98.40%
Other Major Event (list here):	39	0	33	60	35.48%	0.00%	84.62%

Table 1. LTE Child Endorsement Rates.

Question	n	answered yes	answered no	missing	% answered total (out of n = 93)	% answered yes (out of 'n')	% answered no (out of 'n')
Death of a spouse	39	4	35	54	41.94%	10.26%	90.74%
Death of a parent	39	11	28	54	41.94%	28.21%	71.79%
Death of a child	39	3	33	60	35.49%	7.69%	84.62%
Death of a brother or sister	39	6	33	54	41.94%	15.38%	84.62%
Death of another close or important family member	39	30	8	55	40.86%	76.92%	23.08%
Divorce or separation of your parents	39	19	19	55	40.86%	48.72%	51.28%
Lost contact with a parent	39	9	30	54	41.94%	23.08%	76.92%
Parent hospitalized for problem with drugs or alcohol	39	9	30	54	41.94%	23.08%	76.92%
Parent hospitalized for mental illness or emotional problem	39	9	30	54	41.94%	23.08%	76.92%
Parent hospitalized for a physical illness	39	13	26	54	41.94%	33.33%	66.67%
You were separated	39	7	32	54	41.94%	17.95%	82.05%
You were divorced	39	6	32	55	40.86%	15.38%	84.62%
You were convicted of a crime	39	3	36	54	41.94%	33.33%	66.67%
You were incarcerated in a juvenile or adult facility	39	3	36	54	41.94%	33.33%	66.67%
You lived in a foster home	39	2	37	54	41.94%	5.13%	94.87%
You were hospitalized for a problem with drugs or alcohol	39	0	39	54	41.94%	0.00%	100.00%
You were hospitalized for a mental illness or emotional problem	39	2	37	54	41.94%	5.13%	94.87%
You were hospitalized for a physical problem	39	3	36	54	41.94%	33.33%	66.67%
You developed a handicap or disability	39	3	36	54	41.94%	33.33%	66.67%
You were a victim of violence (assault, kidnapping, or other injury by other people)	39	6	33	54	41.94%	15.38%	84.62%
You were homeless or lived in an emergency shelter	39	7	32	54	41.94%	17.95%	82.05%

Table 2. LTE Parent Endorsement Rates.

Question	n	answered yes	answered no	missing	% answered total (out of N = 93)	% answered yes (out of 'n')	% answered no (out of 'n')
Maternal Education	39	0	39	54	41.94%	0.00%	100.00%
Parent unemployment	39	7	32	54	41.94%	17.95%	82.05%
Residential instability/homelessnes	39	8	31	54	41.94%	20.52%	79.48%
Preterm birth	39	2	4	87	6.45%	5.13%	10.26%
Low Birth Weight	39	4	33	56	39.78%	10.26%	84.62%
Maternal Age at the child's birth	39	0	39	54	41.94%	0.00%	100.00%

Table 3. CRC Endorsement Rates.

	Age	Sex	Race	Risk	Internalization	Externalization/ADHD	Time of Day	EF	DCCS	Flanker
Age	--									
Sex	-0.17	--								
Race	0.11	-0.02	--							
Risk	0.38*	-0.24	0.23	--						
Internalization	0.22	-0.04	0.12	0.07	--					
Externalization/ADH	-0.17	0.18	-0.01	0.22	0.33*	--				
Time of Day	0.11	-0.24	0.04	0.00	-0.10	-0.09	--			
EF	0.55**	-0.34*	0.00	0.24	0.11	-0.19	0.01	--		
DCCS	0.41**	-0.41**	0.02	0.32*	0.17	0.02	0.17	0.86**	--	
Flanker	0.47**	-0.17	-0.07	0.19	0.34*	-0.07	-0.09	0.60**	0.36*	--

*p < 0.05, **p < 0.01

Table 4. Pearson Correlations.

	Model 1		Model 2	
	B	Std. Error	B	Std. Error
Age	0.54***	0.14***	0.54***	0.15***
Sex	-0.23	0.12	-0.23	0.13
Race	-0.05	0.12	-0.05	0.13
Risk	-	-	-0.00	0.13
Internalization	-	-	-	-
Externalization/ADHD	-	-	-	-
Time of Day	-	-	-	-

***p < 0.001; **p < 0.01

Table 5. Hypothesized Models.

	Model 3		Model 4		Model 5		Model 6		Model 7	
	B	Std. Error	B	Std. Error	B	Std. Error	B	Std. Error	B	Std. Error
Age	0.54**	0.16**	0.51**	0.17**	0.54***	0.15***	0.52**	0.15**	0.53***	0.14***
Sex	-0.23	0.13	-0.22	0.14	-0.23	0.13	-0.22	0.13	-0.22	0.13
Race	-0.05	0.13	-0.06	0.13	-0.05	0.12	-0.05	0.13	-0.05	0.12
Risk	-0.00	0.13	0.02	0.15	-	-	-	-	-	-
Internalization	-0.01	0.14	0.01	0.16	-0.01	0.14	0.01	0.15	-	-
Externalization/ADHD	-	-	-0.07	0.17	-	-	-0.06	0.16	-0.06	0.14
Time of Day	-	-	-	-	-	-	-	-	-	-
	Model 8		Model 9		Model 10		Model 11		Model 12	
	B	Std. Error	B	Std. Error	B	Std. Error	B	Std. Error	B	Std. Error
Age	0.54***	0.14***	0.53***	0.15***	0.55***	0.15***	0.54***	0.15***	0.53**	0.18**
Sex	-0.25	0.13	-0.24	0.13	-0.25	0.13	-0.25	0.13	-0.24	0.14
Race	-0.05	0.12	-0.05	0.12	-0.05	0.12	-0.05	0.13	-0.05	0.13
Risk	-	-	-	-	-	-	-	-	0.01	0.15
Internalization	-	-	-	-	-0.03	0.14	-0.01	0.15	-0.00	0.16
Externalization/ADHD	-	-	-0.06	0.14	-	-	-0.06	0.16	-0.06	0.17
Time of Day	-0.09	0.12	-0.10	0.12	-0.10	0.12	-0.10	0.12	-0.09	0.12

***$p < 0.001$; **$p < 0.01$

Table 6. Committee Suggested Models.

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	B	Std. Error	B	Std. Error	B	Std. Error	B	Std. Error	B	Std. Error	B	Std. Error
Age	0.40*	0.146*	0.35	0.17	0.33	0.18	0.37	0.20	0.38*	0.17*	0.42*	0.17*
Sex	-0.35*	0.14*	-0.32*	0.15*	-0.33*	0.15*	-0.35*	0.16*	-0.35*	0.15	-0.38*	0.15*
Race	-0.02	0.14	-0.05	0.14	-0.06	0.15	-0.05	0.15	-0.03	0.14	-0.03	0.14
Risk	-	-	0.13	0.15	0.13	0.15	0.09	0.17	-	-	-	-
Internalization	-	-	-	-	0.09	0.16	0.04	0.18	0.09	0.16	0.03	0.17
Externalization/ADHD	-	-	-	-	-	-	0.12	0.20	-	-	0.16	0.18
Time of Day	-	-	-	-	-	-	-	-	-	-	-	-
	Model 7		Model 8		Model 9		Model 10		Model 11		Model 12	
	B	Std. Error	B	Std. Error	B	Std. Error	B	Std. Error	B	Std. Error	B	Std. Error
Age	0.43*	0.16*	0.40*	0.17*	0.42*	0.17*	0.37*	0.17*	0.41*	0.18*	0.36	0.20
Sex	-0.38*	0.15*	-0.34*	0.15*	-0.36*	0.15*	-0.34	0.15	-0.36*	0.15*	-0.34*	0.16*
Race	-0.03	0.14	-0.03	0.14	-0.03	0.14	-0.03	0.14	-0.03	0.15	-0.05	0.15
Risk	-	-	-	-	-	-	-	-	-	-	0.10	0.17
Internalization	-	-	-	-	-	-	0.05	0.14	0.03	0.18	-0.06	0.18
Externalization/ADHD	0.18	0.16	-	-	0.18	0.16	-	-	0.16	0.18	0.12	0.20
Time of Day	-	-	0.04	0.14	0.05	0.14	0.10	0.16	0.05	0.14	0.06	0.14

*$p < 0.05$

Table 7. DCCS Post Hoc Analysis.

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	B	Std. Error	B	Std. Error	B	Std. Error	B	Std. Error	B	Std. Error	B	Std. Error
Age	0.62**	0.19**	0.64**	0.22**	0.57*	0.22*	0.52*	0.23*	0.55**	0.19**	0.52*	0.19*
Sex	-0.07	0.15	-0.07	0.16	-0.07	0.15	-0.04	0.16	-0.07	0.15	-0.04	0.15
Race	-0.19	0.15	-0.19	0.15	-0.21	0.15	-0.22	0.15	-0.21	0.15	-0.22	0.15
Risk	-	-	-0.05	0.17	-0.04	0.16	0.01	0.17	-	-	-	-
Internalization	-	-	-	-	0.26	0.16	0.32	0.17	0.27	0.15	0.32	0.17
Externalization/ADHD	-	-	-	-	-	-	-0.15	0.19	-	-	-0.14	0.18
Time of Day	-	-	-	-	-	-	-	-	-	-	-	-
	Model 7		Model 8		Model 9		Model 10		Model 11		Model 12	
	B	Std. Error	B	Std. Error	B	Std. Error	B	Std. Error	B	Std. Error	B	Std. Error
Age	0.61**	0.20**	0.61**	0.20**	0.61**	0.20**	0.55**	0.19**	0.53*	0.20*	0.52*	0.23*
Sex	-0.07	0.16	-0.09	0.16	-0.09	0.16	-0.09	0.15	-0.06	0.16	-0.06	0.17
Race	-0.19	0.15	-0.18	0.15	-0.18	0.15	-0.20	0.15	-0.21	0.15	-0.21	0.16
Risk	-	-	-	-	-	-	-	-	-	-	0.00	0.18
Internalization	-	-	-	-	-	-	0.26	0.16	0.31	0.17	0.31	0.18
Externalization/ADHD	-0.01	0.17	-	-	-0.01	0.17	-	-	-0.14	0.18	-0.14	0.20
Time of Day	-	-	-0.10	0.14	-0.10	0.14	-0.07	0.14	-0.07	0.14	-0.07	0.14

*p < 0.05; **p < 0.01

Table 8. Flanker Post Hoc Analysis.

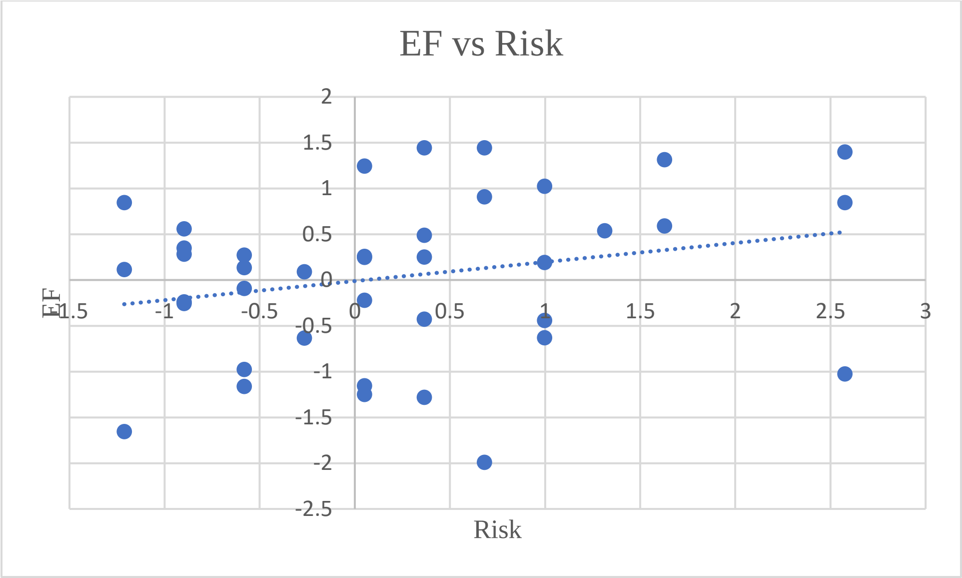

Figure 1. Composite Executive Function Score vs Cumulative Risk.

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