Published in final edited form as:

J Exp Child Psychol. 2017 December ; 164: 1–15. doi:10.1016/j.jecp.2017.07.002.

Intergenerational Associations in Executive Function Between Mothers and Children in the Context of Risk

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Abstract

Executive functioning (EF) is critical for school readiness and other important life skills. Previous investigations have often neglected the important influence of parental EF skills in shaping their own children's EF. This study attempted to replicate recent empirical work that has shown that maternal EF is positively related to child EF. An ecological theoretical framework was used to examine the maternal EF–child EF link in family environments characterized by significant risk and socioeconomic adversity. Data from 38 mother–child dyads revealed that larger maternal working memory capacity was associated with greater child accuracy and slower reaction times on a child-friendly Go/No-Go task of response inhibition, but not on an emotional Go/No-Go task. This finding suggests that in contexts of risk and adversity, slower reaction times, instead of reflecting weaker EF skills, might reflect an adaptive skill; that is, exercising appropriate caution and careful responding on a challenging task. Results provide additional evidence of an intergenerational link between maternal EF and child EF and yield new insights into the nature of EF in adverse environments.

Keywords

Executive function; inhibitory control; working memory; mothers; children; socioeconomic risk

Introduction

Executive functioning (EF) comprises a set of higher order cognitive processes that support the ability to regulate one's behavior (Best & Miller, 2010; Diamond, 2013). Often used interchangeably with terms such as *self-regulation* or *cognitive control*, executive functioning is typically conceptualized as three distinct but interrelated processes (e.g., Diamond, 2016): cognitive flexibility (paying attention and shifting attention between tasks),

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inhibitory control (controlling and withholding one's responses appropriately), and working memory (remembering rules while simultaneously engaging in other tasks).

Although consistent and compelling evidence indicates that EF—particularly working memory and inhibitory control—is a powerful predictor of child and adult outcomes (e.g., Blair & Razza, 2007; Diamond, 2016; Diamond, Barnett, Thomas, & Munro, 2007; Friedman, Miyake, Robinson, & Hewitt, 2011; McClelland et al., 2007; McClelland, Acock, Piccinin, Rhea, & Stallings, 2013; Moffitt et al., 2011; Tangney, Baumeister, & Boone, 2004), these outcomes have often been investigated separately, with little regard to the meaningful influences that parents, particularly mothers, exert on their children. Given evidence that children develop higher order self-regulatory skills in part through exchanges with their caregivers (e.g., Cipriano-Essel, Skowron, Stifter, & Teti, 2013), we were interested in the extent to which child EF is influenced by similar EF abilities in parents. Because EF skills predict early school success and later outcomes, it was also important to explore how contextual factors, such as the broad home and family environment, might promote or impede the development of these skills. Therefore, a joint exploration of EF processes at the mother and child level would enable us to better understand how children develop EF skills and to what extent these skills are influenced by environmental factors. Our study was informed by an ecological theoretical framework to explore the link between maternal and child EF in the relatively understudied population of households characterized by significant risk and socioeconomic adversity.

Executive Functioning in Young Children and Adults

Early childhood is characterized by individual differences that underlie rapid growth in EF (Montroy, Bowles, Skibbe, McClelland, & Morrison, 2016). Inhibitory control has been a particular focus of research attention because it is among the earliest EF components to develop in young children (Diamond, 2016) and is fundamental to regulating one's behaviors during the transition to formal schooling. Inhibitory control and working memory appear to be correlated in young children (Senn, Espy, & Kauffman, 2004), with cognitive flexibility (or set shifting) building on these two foundational processes (e.g., Morasch, Raj, & Bell, 2013). Factor models representing child EF are more likely to indicate two factors—inhibition and working memory—rather than the three factors more commonly found in adult EF data (e.g., Hughes, Ensor, Wilson, & Graham, 2010; St Clair-Thompson & Gathercole, 2006; Wiebe et al., 2011). In research that has examined theory of mind, working memory and inhibitory control together predicted theory of mind development better than did either subskill alone (Carlson, Moses, & Breton, 2002). This finding suggests that these two subskills may interact in consequential ways to predict important cognitive and social outcomes for children.

Because the componential nature of EF is more evident in adults than in children (e.g., Miyake et al., 2000; Wiebe, Espy, & Charak, 2008), an examination of specific EF processes, particularly working memory, might be more appropriate when studying adult populations. Working memory capacity—a measure of working memory—reflects the number of items that can be successfully stored in memory at any given time (e.g., Engle, 2002) and is associated with the ability to use cognitive reappraisal and to self-regulate in

stressful situations that are common in the parenting context (Deater-Deckard, Sewell, Petrill, & Thompson, 2010). Results from the change detection task indicate that working memory capacity is correlated with higher order cognitive abilities, indicating that this measure might provide important information about individual differences in fundamental cognitive processes (Cowan et al., 2006; Rose, Feldman, & Jankowski, 2012; see Simmering, 2017, for a review). A low level of working memory is associated with low socioeconomic status (SES; Hackman et al., 2014), which in turn predicts higher levels of stress, poorer physical health, and greater incidence of psychopathology (Adler et al., 1994). EF capabilities are closely related with caregiving quality and parenting behaviors (Azar, Reitz, & Goslin, 2008), and individual differences in working memory capacity also have been linked to caregiving behaviors (e.g., Sturge-Apple, Suor, & Skibo, 2014). Deficits in maternal working memory may be associated with difficulties in regulating emotions and behavior, thereby negatively influencing parenting practices and leading to adverse child outcomes (Deater-Deckard et al., 2010). On the other hand, better working memory might reflect a greater ability to keep track of multiple children and tasks in the home and to manage parenting activities accordingly.

Research on EF has traditionally studied children and adults separately, thus, far less is known about relations between adult EF and child EF. Recent theorizing has emphasized the importance of ecological models (e.g., Bronfenbrenner & Morris, 2006) and has recognized that the development of EF is associated with both proximal and distal factors, including genetics and home and school environments (e.g., Blair & Raver, 2015; Bridgett, Burt, Edwards, & Deater-Deckard, 2015; Fay-Stammach, Hawes, & Meredith, 2014). Deater-Deckard (2014) has proposed an ecological model of intergenerational transmission and interpersonal processes of self-regulation in which complex pathways exist between parent responses, parent self-regulation, child self-regulation, and child responses, with important contextual factors, such as development and the home/family environment, influencing these pathways. This heuristic model posits that parents transmit self-regulation (i.e., EF) to their children through interacting socialization and biological mechanisms, and that contextual features of the home and family, such as socioeconomic risk factors, might influence this pathway. Consistent with this model, one might predict not only that maternal EF would be correlated with child EF, but also that this pathway might manifest differently in the context of risk and adversity, with important implications for our understanding of individual differences in EF and how different contexts might inform approaches to remediating EF deficits and promoting EF skills. This theoretical framework provides a way to situate empirical work exploring both parental and child factors in the study of EF. In our study, we sought to explore one important aspect of this model: the direct link between maternal EF and child EF.

Executive Functioning in the Context of Risk and Adversity

Research on maternal–child EF pathways has traditionally focused on individuals experiencing low risk and adversity. Empirical research in these upper-middle-class populations has generated somewhat mixed results. In one adoption study, no association was found between biological mothers' performance on a Stroop task and performance by their 27-month-old children (adopted by other families) on a gift delay task and age-

appropriate Stroop task of inhibitory control (Leve et al., 2013). The authors acknowledge that their highly educated, high-income sample of participants may limit the interpretation of their findings. On the other hand, Cuevas and colleagues (Cuevas, Deater-Deckard, Kim-Spoon, Wang, et al., 2014; Cuevas, Deater-Deckard, Kim-Spoon, Watson, et al., 2014) found a modest but stable association between maternal EF and child EF at child ages 24 and 48 months in a sample of highly educated families. However, we do not know if these associations hold in the context of sociodemographic risk.

Deficits in EF development are associated with adverse environments characterized by poverty or household instability (see McClelland, Leve, & Pears, 2016, for a review) and as such, may result in EF manifesting differently in mothers and children from higher risk environments than in those from more stable households. Resource limitations and social stress represent two theoretical perspectives on the impact of SES on EF development (Clark, James, & Espy, 2017). Research has shown that maternal EF and paternal EF are associated with EF in adolescent children identified as being at risk for developing a substance use disorder, even after controlling for IQ (Jester et al., 2009). Young children raised in poverty, in single-parent households, and in the care of mothers with mental health issues show poorer EF development than do children not exposed to these risk factors (Rhoades, Greenberg, Lanza, & Blair, 2011). In environments characterized by high household chaos, harsh parenting was associated with conduct problems in a socioeconomically diverse sample of children ages 3 to 7 years, but only in families headed by mothers who exhibited low EF (Deater-Deckard, Wang, Chen, & Bell, 2012). In another empirical investigation, results indicated that low household income predicted weaker executive control and less ability in children to tolerate reward delay, with cumulative risk accounting for the effect on executive control but not on delay ability (Lengua et al., 2015). Taken together, these findings suggest that the deleterious effects of environment on EF development may act through multiple pathways.

However, these studies have focused either on older children or relatively low-risk families, or have not explicitly explored the direct link between maternal EF and child EF. Our study sought to address this gap by exploring whether findings demonstrating a link between maternal EF and child EF can be replicated in families and young children who experience significant levels of adversity, with important implications for our understanding of risk and resilience in the development of EF in early childhood.

Measuring Executive Functioning in Children

The debate about the unitary and componential structure of EF is reflected in the many different measurement tools that have been developed to explore EF processes in children. The “conceptual clutter and measurement mayhem” that have marked the study of EF has been a challenge for the field as it seeks to synthesize the literature and identify directions for future research (Morrison & Grammer, 2016). Measurement issues are even more salient in studies that seek to measure EF in both adults and children living in environments characterized by risk and adversity. Specifically, home environments that impede the development of visual, semantic, linguistic, and motor demands that bear on EF processes might lead to deficits in EF and make the accurate measurement of EF more difficult (Clark,

Chevalier, et al., 2017). Moreover, children from high-risk environments might experience deficits in emotion regulation, including the ability to monitor and evaluate their emotional reactions (e.g., Thompson & Calkins, 1996), which might affect how they perform on tasks of behavioral inhibition.

In our study we sought to address these challenges by using a set of well-validated, developmentally appropriate measures of EF. Tasks associated with child EF often include both inhibitory control and working memory demands. For example, in a Go/No-Go paradigm, respondents have to not only inhibit responses to certain stimuli, but also remember the decision rules for responding (or not responding) to one type of stimuli versus another, making the task a particularly useful tool for measuring EF in children. Computerized assessment in standardized child-friendly Go/No-Go tasks can be used to measure fine-grained individual differences in inhibition by identifying accuracy and reaction times on cognitively challenging tasks that place demands on working memory. We used a standard child-friendly Go/No-Go task called the Fish/Shark game that is highly engaging and fun for young children. We also used an emotional Go/No-Go task that requires different inhibition responses to pictures of different emotional reactions, which we conjectured would provide additional insights into EF processes in our at-risk population.

Study Aims and Hypotheses

We sought to replicate previous work that has demonstrated a link between maternal EF and child EF. We also sought to extend this work by exploring this pathway in the context of heightened risk and by including standardized inhibitory control assessments in our measurement of child EF. Our primary aim was to explore whether maternal EF, as measured by maternal working memory capacity, was related to child EF, as measured by children's performance on two distinct Go/No-Go tasks of inhibitory control. Specifically, we hypothesized that larger maternal working memory capacity would be associated with better child accuracy and faster reaction times on the Fish/Shark Go/No-Go task. We did not make specific predictions regarding the emotional Go/No-Go child task, because mixed evidence from previous studies suggests that at-risk children may respond differently to different emotions depending on situational demands and other individual factors (e.g., Thompson & Calkins, 1996). We leave open the possibility that the hypothesized positive association between maternal working memory capacity and child inhibitory control might manifest differently in an affective context.

Method

Participants

Participants were drawn from a study of cardiac and cognitive regulation in families and children. Participants were recruited through child welfare services, Early Head Start, and through an ongoing study of mothers who had been involved with child welfare services as children. Study procedures are described in greater detail elsewhere (Clark, Skowron, Giuliano, & Fisher, 2016). Fifty-two mother-child dyads were recruited through child welfare services and Early Head Start in a mid-sized city in the Pacific Northwest; complete behavioral data across all EF variables were available for 38 mother-child dyads (17 boys,

21 girls). Data were missing primarily due to child refusal or inability to complete one or more tasks, which is not uncommon in study samples characterized by higher risk and adversity. Reflecting the communities from which participants were recruited, 34 mothers identified their children as European American/White, 12 as Hispanic American/Latino, 6 as Native American/Alaskan Aleut, and 4 as African American/Black (some mothers marked more than one race/ethnicity category). On average, mothers were age 30.87 years ($SD = 6.44$, range = 21.58–48.08), and children were age 4.43 years ($SD = 0.86$, range = 3.08–6.83). Twenty-three mothers (60.5%) reported a highest educational attainment of high school or less, and monthly household income estimates ranged from \$300 to \$5,833.33 per month ($M = \$2,146.99$, $Mdn = \$2,000.00$, $SD = \$1,140.91$), with 20 families (52.6%) living below the U.S. federal poverty guidelines at the time of their visit. Families were characterized by moderate risk as assessed using a cumulative risk scale ($M = 3.00$, $SD = 1.91$, range = 0–7; adapted from Evans & Kim, 2007). Children who were excluded from the analysis due to incomplete data did not differ significantly from children who were included on child gender, maternal education, household income, and cumulative risk. However, children excluded from the analysis were younger in age, $t(49) = -2.34$, $p = .02$.

Procedure and Measures

After prescreening, families arrived to the laboratory for a 2.5-hour lab visit. Once parental informed consent and child assent were obtained, electrodes were applied to mother and child for monitoring cardiac data. Then the dyad watched a 5-minute neutral video, after which mother and child engaged in a scripted interaction task (Clark et al., 2016). After the joint interaction task, mothers and children were led to separate rooms, where each completed age-appropriate assessments of EF.

Mothers completed a visual change detection measure of working memory (Luck & Vogel, 1997; Vogel, Woodman, & Luck, 2001) while seated at a desk with a computer monitor and response pad. Each trial of the task began with the presentation of two, three, or six colored squares for 150 milliseconds (ms) in randomized locations on a computer screen. The squares were then removed from the screen for a delay period of 1,000 ms. Then the squares were displayed again but with one of the squares circled, and this square was presented in either the same color as originally presented (50% of trials) or presented in a different color (50% of trials). Participants were instructed to respond “same” or “change” by pressing a left or right button, respectively. To emphasize accuracy over speed, the test array remained on the display until the participant responded. Twelve practice trials were presented to each participant before the task began. The task was split into six blocks of 60 trials each, totaling 360 trials with 120 trials at each set size (2, 3, and 6) and evenly divided between “same” and “change” trials. Individual estimates of working memory capacity (k) were calculated for each participant by using a standard formula (e.g., Cowan, 2001), where $k = \text{set size} \times (\text{hit rate} - \text{alarm rate})$, averaged across all three set sizes.

Children completed two inhibitory control tasks. In the Fish/Shark Go/No-Go task (described in full in Wiebe, Sheffield, & Espy, 2012)—a child-friendly variant of classic inhibitory control Go/No-Go target discrimination tasks—children were asked to respond by pressing a button when a picture of a fish was presented (Go) in order to catch the fish with a

net, but to inhibit a response when a shark was presented (No-Go). If the child incorrectly pressed the button for the shark, a picture of a broken net appeared accompanied by a buzzing sound. After a practice block of 10 Go trials, a block of 30 Go trials and 10 No-Go trials was presented. Stimuli were presented in E-Prime for 1,500 ms with an interstimulus interval (ISI) of 100 ms; children were able to respond during stimulus presentation and the subsequent ISI. In the Emotional Go/No-Go task (adapted from Pollak, Klorman, Thatcher, & Cicchetti, 2001), children were asked to respond with a button press when a happy face was presented and to inhibit a response when an angry face was presented. Following four practice trials, four blocks of trials were presented. In Block 1 (18 trials), children were asked to respond to happy faces and inhibit response to angry faces. Block 2 (18 trials) was reversed, requiring children to respond with a button press to angry faces and inhibit response to happy faces. In Blocks 3 and 4, neutral faces were introduced; Block 3 (20 trials: 4 happy, 8 angry, 8 neutral) required children to respond to angry faces, whereas Block 4 (20 trials: 8 happy, 4 angry, 8 neutral) required that children respond to the happy faces. Stimuli were displayed for 1,000 ms with an ISI of 500 ms; children were able to respond during stimulus presentation and the subsequent ISI.

Analytical Method

Two ordinary least squares regression models, one for each Go/No-Go task, were specified and tested. We limited our dependent variables to accuracy and reaction time on both Go/No-Go tasks. Accuracy was calculated as the percentage of correct responses on Go trials (hit rate), as well as the percentage of incorrect responses on No-Go trials (false alarm rate). D-prime (d')—another indicator of accuracy—is a measure of sensitivity based on signal detection theory, and was calculated by standardizing the hit rate and false alarm rate and then taking the difference between these two values. Because d' values less than or equal to zero indicate that the respondent could not reliably discriminate signal (Go stimuli) from noise (No-Go stimuli), these children were excluded from the regression analysis. Reaction time was calculated as the average duration (in milliseconds) for responding correctly to a Go trial (excluding correct nonresponses on No-Go trials). Accuracy and reaction time are useful indicators of EF in that they provide a continuous metric of performance on cognitively challenging tasks that tap EF skills. Particularly ideal for younger children, these measures may be less prone to the floor or ceiling effects that are common in many behavioral measures (e.g., Nelson, James, Chevalier, Clark, & Espy, 2016). In each model, we estimated the unique effect of maternal working memory capacity on child performance in each Go/No-Go task and included child age, child gender, and maternal education as control variables. Given our small sample size, we limited the number of control variables in the models. Statistical analyses were conducted in Stata 13.1.

Results

Descriptive Statistics

Descriptive statistics for maternal working memory and child EF measures are presented in Table 1. Bivariate correlations are presented in Table 2. Accuracy and reaction times across both Go/No-Go tasks were significantly correlated with each other, indicating that both tasks were tapping into overlapping mechanisms of inhibitory control.

Fish/Shark Go/No-Go

Table 3 presents regression estimates of maternal working memory capacity on child accuracy and reaction on the Fish/Shark Go/No-Go task. Results indicated that better maternal working memory performance was related to better child accuracy on Go trials but not on No-Go trials. Maternal working memory capacity was also related to larger d' in children. Results also indicated that better maternal working memory performance was related to slower child reaction time on correct trials, though this effect was significant at trend level ($p = .052$). Both effects were significant even after controlling for child gender, child age, and maternal education, variables that have been shown to be related to child EF in previous investigations (e.g., Matthews, Ponitz, & Morrison, 2009).

Emotional Go/No-Go

Table 4 presents regression estimates of maternal working memory capacity on child accuracy and reaction time on the Emotional Go/No-Go task. Maternal working memory capacity was positively associated with child accuracy on Go trials on happy faces, as well as d' on happy faces, but these effects are difficult to reconcile with the overall pattern of null findings. Therefore, in contrast to the Fish/Shark task, maternal working memory capacity was not significantly related to child accuracy and reaction time on the Emotional Go/No-Go task. In addition, t -tests indicated that there were no mean differences on accuracy, $t(37) = -1.50$, $p = .14$, and reaction time, $t(37) = -.68$, $p = .50$, as a function of emotion type (happy face or angry face).

Discussion

The purpose of our study was to replicate previous research that has indicated that maternal EF explains significant variance in child EF during the transition to school period, and to extend this research by examining these associations in a sample characterized by risk and socioeconomic adversity. We used two distinct child-friendly Go/No-Go tasks of inhibitory control to better understand the nature of inhibitory control in preschool-age children and the relation between maternal and child EF. Consistent with our hypothesis, we found that larger maternal working memory capacity was significantly related to greater child accuracy on Go trials and a larger d' on a traditional Go/No-Go task of inhibitory control. However, contrary to our prediction, larger maternal working memory capacity was related to slower, not faster, reaction times on the same task. Maternal working memory capacity was not related to child EF on the emotional Go/No-Go task.

Heterogeneous Findings as a Function of Task

As numerous studies have indicated, the reliable measurement of child EF, particularly during the transition to school period, has been notoriously challenging (see Morrison & Grammer, 2016, for a review). There is still a debate as to whether EF is better understood as comprising three distinct subskills or one unitary construct in early childhood (Miyake et al., 2000; Wiebe et al., 2008; Wiebe et al., 2011). Given the rapid development of these skills during early childhood, floor and ceiling effects on EF measures complicate the ability of researchers to reliably measure these skills in a consistent way over time. Our exploration of

accuracy and reaction time on standardized and computerized EF tasks represents one possible method of minimizing these challenges.

That said, we must reconcile the apparent contradiction that maternal working memory capacity was related to child EF measures on the Fish/Shark Go/No-Go task but not on the emotional Go/No-Go task. We propose that for our sample, the Fish/Shark task—the only task for which we observed significant effects—may have been a more appropriate measure of inhibitory control than was the emotional Go/No-Go task. The Fish/Shark task is a variant of the classic inhibitory control task; similar child-friendly tasks such as the Go/No-Go Zoo Game have been used with considerable success with young children on both behavioral and electrophysiological indices of EF (e.g., Grammer, Carrasco, Morrison, & Gehring, 2014; Kim et al., 2016; Roos, Pears, Bruce, Kim, & Fisher, 2015). A primary advantage of the Go/No-Go paradigm as a measure of inhibitory control is its demonstrated association with specific patterns of neural functioning (e.g., Wiebe et al., 2012). The child-friendly and engaging theme of the Fish/Shark game may have facilitated a greater understanding of the rules and promoted increased attention and persistence throughout the task.

In contrast, the emotional Go/No-Go task is less intuitive (responding to happy versus angry faces without a meaningful rationale for doing so), and also introduces an affective component that may elicit responses distinct from EF or inhibitory control. It may also be that in our sample of at-risk children—who may have heightened responses to stress given their increased exposure to adverse experiences—emotionally salient images (particularly negatively-valenced emotions such as anger) may interfere with their inhibitory control mechanisms and affect their performance, yielding indicators that do not accurately reflect children's underlying EF capacities. Although research has demonstrated that undergraduate students high in working memory capacity are better able to suppress expressions of negative emotions and to appraise emotional stimuli in an unemotional manner (Schmeichel, Volokhov, & Demaree, 2009), it does not provide insights into whether this link between working memory and emotion might be present when examining mothers and children. Future directions might include an exploration of the autonomic, behavioral, or electrophysiological responses associated with different emotions in order to directly test whether and how responses to affective stimuli are related to children's EF in the context of risk. Recent research on autonomic physiology has identified heart rate variability (HRV) and respiratory sinus arrhythmia (RSV) as potential biomarkers of EF (see Holzman & Bridgett, 2017, for a review); future directions might include an investigation of whether and how these biomarkers might relate across mother-child dyads.

Maternal Working Memory Capacity and Child Accuracy

Consistent with our hypothesis, we found that larger maternal working memory capacity was related to increased child accuracy on the Fish/Shark task on Go trials, but not on No-Go trials. We also found a positive association between maternal working memory capacity and d' , a measure of sensitivity based on signal detection theory. These effects remained significant even after controlling for child gender, child age, and maternal education, variables that tend to be highly associated with EF. Our results replicate previous findings from across the child developmental span that have indicated a positive association between

parent EF and child EF (Cuevas, Deater-Deckard, Kim-Spoon, Wang, et al., 2014; Cuevas, Deater-Deckard, Kim-Spoon, Watson, et al., 2014; Jester et al., 2009). Notably, the dissociation that we observed as a function of trial type (Go vs. No-Go trials) indicates that Go trials in children are more meaningfully related to maternal working memory capacity compared to No-Go trials. While No-Go trial performance typically requires greater cognitive control due to the need to inhibit a prepotent response, recent research indicates that Go trials might be indexing context monitoring processes closely related to attentional demands associated with the cognitive flexibility dimension of EF (e.g., Chatham et al., 2012; Chevalier, Chatham, & Munakata, 2014). Although a causal link cannot be concluded from our cross-sectional data, our findings indicate that maternal influences may play an important role in the development of children's EF in high-risk populations during the critical transition to school period.

Maternal Working Memory Capacity and Child Reaction Times

Contrary to our hypothesis, we found that larger maternal working memory capacity was related to children's slower reaction times on the Fish/Shark Go/No-Go task. Typically, better EF skills are associated with faster reaction times and account for increased efficiency of processing information and responding, but studies that have demonstrated this effect have been conducted for the most part with children from middle- and upper-middle-class backgrounds. Particularly germane to our investigation, a previous study that used the Fish/Shark Go/No-Go task in similar-age children with a similar socioeconomic risk profile found that better cognitive skills were related to slower responding in children assessed between ages 3 and 3.75 years but to faster responding in children assessed between ages 4.5 and 5.25 years (Wiebe et al., 2012). Contrary to those findings, our data indicated that accuracy and reaction times on Go trials were not significantly related to each other, and *t*-tests comparing reaction times between younger and older children in our sample did not detect group mean differences (using a median split of 4.25 years [51 months] of age, such that younger children in our study sample ranged in age from 37 to 50 months and older children ranged in age from 51 to 82 months).

We propose that slower responding in this sample of preschool-age children may in fact indicate appropriate caution and careful responding on a challenging task, reflecting an adaptive skill set, especially for children in contexts of risk and adversity, instead of reflecting inefficient processing capacities or weaker EF skills. That is, children may be going slower because they have decided to prioritize accuracy over speed, even though experimenters instructed children to "go as fast as you can so the fish don't get away, but try not to make any mistakes." Put another way, there might be individual differences in how children operationalize the "speed-accuracy tradeoff" common in these inhibitory control tasks; these differences might be driven by both maternal and socioeconomic factors. Indeed, research indicates that EF and EF-related processes are different in high-risk individuals because of factors such as harsh parenting, child maltreatment, stress, and other variables (Deater-Deckard et al., 2012; Rhoades et al., 2011). Our observed effect may represent one example of how EF processes manifest differently in at-risk populations. In fact, a growing body of research has demonstrated the seemingly counterintuitive finding that higher cumulative adversity predicts better—not worse—EF in children (e.g., Pears & Fisher, 2005;

Pears et al., 2008; Roos, Kim, Schnabler, & Fisher, 2016). The interpretation is that early life stressors might cue the body to accelerate biological development, including EF and cognitive control processes. Our finding that better maternal working memory performance is related to slower reaction times provides additional evidence that adversity is associated with EF in complex ways, particularly when an intergenerational component is introduced.

Although no significant correlations were observed between a family's cumulative risk index and child's reaction times on either Go/No-Go task, our sample may have been too homogeneous from a risk/adversity perspective to properly test the validity of this interpretation. Moreover, our data did not allow us to determine the extent to which slower responding by children is influenced by socioeconomic adversity or better maternal working memory, or a combination of both effects. Future directions for research might include an assessment of both high-risk and low-risk participants on the same battery of EF measures, with subgroup analyses allowing for a more direct comparison of effects. It is also difficult to determine whether slower responses might have been a function of children's motivational orientations toward achievement, which have been shown to affect task engagement and performance (e.g., Wigfield & Eccles, 2000; see Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2006, for a review). Including measures of motivation and task engagement would enable us to explore the possibility that socioeconomic and household factors might interact with individual differences in motivational processes to yield different EF growth trajectories in early childhood.

Limitations and Directions for Future Research

Although our sample size of 38 mother-child dyads with complete data is small, it is comparable with that of other dyadic investigations of EF. Moreover, a close examination of the standard errors on the maternal working memory measure across both child EF regression models do not seem to indicate that our lack of results stemmed from random noise. That is, the standard errors for child accuracy and reaction time for the Fish/Shark Go/No-Go task, though smaller than their corresponding values in the emotional Go/No-Go task, are not significantly smaller, indicating that our Fish/Shark estimates are likely to be true effects. A larger sample size would allow for greater precision and confidence in our estimates and might elevate our trend-level effect of maternal working memory capacity on children's reaction time to conventional significance levels. Nevertheless, our study contributes to the growing literature that indicates meaningful associations between maternal EF and child EF, and extends this work by demonstrating that this maternal-child link is also present in a sample of high-risk families and children.

We used a working memory capacity assessment as our measure of maternal EF. Although there were numerous advantages for operationalizing EF in this way, having a single measure of maternal EF limits the conclusions we can draw regarding maternal-child EF pathways. However, our particular measure of working memory is a major strength of our study because this change detection task has been useful in detecting meaningful individual differences in working memory and EF in general (e.g., Feldman Barrett, Tugade, & Engle, 2004), and working memory capacity in adults is related to performance on EF tasks and other higher order cognitive tasks (e.g., Engle, 2002; Kane & Engle, 2003). That said, future

research should consider including maternal assessments of cognitive flexibility and inhibitory control in order to determine the extent to which our results are generalizable to different EF component skills.

Adopting an intergenerational theoretical framework allows researchers to ask questions at multiple dyadic levels, thereby illuminating the nature and development of EF in ways that are unavailable when investigating parents or children separately. Consistent with an ecological theoretical framework (e.g., Bridgett et al., 2015), we might expect the quality of maternal caregiving behavior to mediate (fully or in part) the association between maternal EF and child EF. Future directions might include the coding of mother-child behaviors in various interactive contexts in order to explore this potential mediating link.

Conclusion

Our study explored the extent to which maternal EF is a predictor of child EF in a sample of high-risk families and children. We found that larger maternal working memory capacity was related to greater child accuracy and more careful responding on a classic child-friendly task of inhibitory control. Slower responding in children who grow up in environments characterized by significant risk and adversity might reflect adaptive behaviors that promote positive outcomes for these children. Findings suggest that maternal skills can influence skills important for complex, goal-directed activity in young children, with implications for our understanding of the various influences that shape the early EF skills that are important for school and life success.

Acknowledgments

The authors thank members of the University of Oregon Family Biobehavioral Health Lab, with particular gratitude to Rose Jeffries, Mora A. Reinka, Kadie Johnson, and Amala Shetty for their assistance in data collection and processing, Carrie Clark for her invaluable consultation, and Cheryl Mikkola for her support in the preparation of this manuscript. We also thank the families who shared their experiences and time with us. This project was supported by start-up funds and National Institutes of Health grants R01MH079328 (PI: Elizabeth A. Skowron) and P50DA035763 (PI: Philip A. Fisher).

References

- Adler NE, Boyce T, Chesney MA, Cohen S, Folkman S, Kahn RL, Syme SL. Socioeconomic status and health: The challenge of the gradient. *American Psychologist*. 1994; 49:15–24. <http://dx.doi.org/10.1037/0003-066X.49.1.15>. [PubMed: 8122813]
- Azar ST, Reitz EB, Goslin MC. Mothering: Thinking is part of the job description: Application of cognitive views to understanding maladaptive parenting and doing intervention and prevention work. *Journal of Applied Developmental Psychology*. 2008; 29:295–304. <http://dx.doi.org/10.1016/j.appdev.2008.04.009>.
- Best JR, Miller PH. A developmental perspective on executive function. *Child Development*. 2010; 81(6):1641–1660. <http://dx.doi.org/10.1111/j.1467-8624.2010.01499.x>. [PubMed: 21077853]
- Blair C, Raver CC. School readiness and self-regulation: A developmental psychobiological approach. *Annual Review of Psychology*. 2015; 66:711–731. <http://dx.doi.org/10.1146/annurev-psych-010814-015221>.
- Blair C, Razza RP. Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*. 2007; 78(2):647–663. <http://dx.doi.org/10.1111/j.1467-8624.2007.01019.x>. [PubMed: 17381795]

- Bridgett DJ, Burt NM, Edwards ES, Deater-Deckard K. Intergenerational transmission of self-regulation: A multidisciplinary review and integrative conceptual framework. *Psychological Bulletin*. 2015; 141(3):602–654. <http://dx.doi.org/10.1037/a0038662>. [PubMed: 25938878]
- Bronfenbrenner, U., Morris, PA. The bioecological model of human development. In: Lerner, RM., editor. *Handbook of child development: Vol. 1. Theoretical models of human development*. 6th. Hoboken, NJ: Wiley; 2006. p. 793–828.
- Carlson SM, Moses LJ, Breton C. How specific is the relation between executive function and theory of mind? Contributions of inhibitory control and working memory. *Infant and Child Development*. 2002; 11(2):73–92. <http://dx.doi.org/10.1002/icd.298>.
- Chatham CH, Claus ED, Kim A, Curran T, Banich MT, Munakata Y. Cognitive control reflects context monitoring, not motoric stopping, in response inhibition. *PLoS One*. 2012; 7(2):1–13.
- Chevalier N, Chatham CH, Munakata Y. The practice of going helps children to stop: The importance of context monitoring in inhibitory control. *Journal of Experimental Psychology: General*. 2014; 143(3):959–965. [PubMed: 24512561]
- Cipriano-Essel EA, Skowron EA, Stifter CA, Teti DM. Heterogeneity in maltreated and non-maltreated preschool children's inhibitory control: The interplay between parenting quality and child temperament. *Infant and Child Development*. 2013; 22:501–522. <http://dx.doi.org/10.1002/icd.1801>. [PubMed: 24729743]
- Clark CAC, Chevalier N, Nelson JM, James TD, Garza JP, Choi HJ, Espy KA. The changing nature of executive control in preschool: I. Executive control in early childhood. *Monographs of the Society for Research in Child Development*. 2017; 81(4):7–29. <http://dx.doi.org/10.1111/mono.12268>.
- Clark CAC, James TD, Espy KA. IV. The changing nature of executive control in preschool: IV. A new look at the implications of the socio-familial context for young children's executive control: Clarifying the mechanisms of individual differences. *Monographs of the Society for Research in Child Development*. 2017; 81(4):69–95. <http://dx.doi.org/10.1111/mono.12271>.
- Clark CAC, Skowron EA, Giuliano RJ, Fisher PA. Intersections between cardiac physiology, emotion regulation and interpersonal warmth in preschoolers: Implications for drug abuse prevention from translational neuroscience. *Drug and Alcohol Dependence*. 2016; 163:S60–S69. [PubMed: 27306733]
- Cowan N. The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and Brain Sciences*. 2001; 24:87–114. <http://dx.doi.org/10.1017/S0140525X01003922>. [PubMed: 11515286]
- Cowan N, Fristoe NM, Elliott EM, Brunner RP, Sauls JS. Scope of attention, control of attention, and intelligence in children and adults. *Memory and Cognition*. 2006; 34(8):1754–1768. <http://dx.doi.org/10.3758/BF03195936>. [PubMed: 17489300]
- Cuevas K, Deater-Deckard K, Kim-Spoon J, Wang Z, Morasch KC, Bell MA. A longitudinal intergenerational analysis of executive functions during early childhood. *British Journal of Developmental Psychology*. 2014; 32:50–64. <http://dx.doi.org/10.1111/bjdp.12021>. [PubMed: 25284715]
- Cuevas K, Deater-Deckard K, Kim-Spoon J, Watson AJ, Morasch KC, Bell MA. What's mom got to do with it? Contributions of maternal executive function and caregiving to the development of executive function across early childhood. *Developmental Science*. 2014; 17(2):224–238. <http://dx.doi.org/10.1111/desc.12073>. [PubMed: 24410963]
- Deater-Deckard K. Family matters: Intergenerational and interpersonal processes of executive function and attentive behavior. *Current Directions in Psychological Science*. 2014; 23(3):230–236. <http://dx.doi.org/10.1177/0963721414531597>. [PubMed: 25197171]
- Deater-Deckard K, Sewell MD, Petrill SA, Thompson LA. Maternal working memory and reactive negativity in parenting. *Psychological Science*. 2010; 21:75–79. <http://dx.doi.org/10.1177/0956797609354073>. [PubMed: 20424026]
- Deater-Deckard K, Wang Z, Chen N, Bell MA. Maternal executive function, harsh parenting, and child conduct problems. *Journal of Child Psychology and Psychiatry*. 2012; 53:1084–1091. <http://dx.doi.org/10.1111/j.1469-7610.2012.02582.x>. [PubMed: 22764829]
- Diamond A. Executive functions. *Annual Review of Psychology*. 2013; 64:135–168. <http://dx.doi.org/10.1146/annurev-psych-113011-143750>.

- Diamond, A. Why improving and assessing EFs early in life is critical. In: Griffin, JA. McArdle, P., Freund, L.S., editors. Executive function in preschool-aged children. Washington, DC: American Psychological Association; 2016. p. 11-43.
- Diamond A, Barnett WS, Thomas J, Munro S. Preschool program improves cognitive control. *Science*. 2007; 318:1387–1388. <http://dx.doi.org/10.1126/science.1151148>. [PubMed: 18048670]
- Engle RW. Working memory capacity as executive attention. *Current Directions in Psychological Science*. 2002; 11(1):19–23. <http://dx.doi.org/10.1111/1467-8721.00160>.
- Evans GW, Kim P. Childhood poverty and health: Cumulative risk exposure and stress dysregulation. *Psychological Science*. 2007; 18(11):953–957. <http://dx.doi.org/10.1111/j.1467-9280.2007.02008.x>. [PubMed: 17958708]
- Fay-Stammach T, Hawes DJ, Meredith P. Parenting influences on executive function in early childhood: A review. *Child Development Perspectives*. 2014; 8(4):258–264. <http://dx.doi.org/10.1111/cdep.12095>.
- Feldman Barrett L, Tugade MM, Engle RW. Individual differences in working memory capacity and dual-process theories of the mind. *Psychological Bulletin*. 2004; 130(4):553–573. <http://dx.doi.org/10.1037/0033-2909.130.4.553>. [PubMed: 15250813]
- Friedman NP, Miyake A, Robinson JL, Hewitt JK. Developmental trajectories in toddlers' self-restraint predict individual differences in executive functions 14 years later: A behavioral genetic analysis. *Developmental Psychology*. 2011; 47(5):1410–1430. <http://dx.doi.org/10.1037/a0023750>. [PubMed: 21668099]
- Grammer JK, Carrasco M, Gehring WJ, Morrison FJ. Age-related changes in error processing in young children: A school-based investigation. *Developmental Cognitive Neuroscience*. 2014; 9:93–105. <http://dx.doi.org/10.1016/j.dcn.2014.02.001>. [PubMed: 24631799]
- Hackman DA, Betancourt LM, Gallop R, Romer D, Brodsky NL, Hurt H, Farah MJ. Mapping the trajectory of socioeconomic disparity in working memory: Parental and neighborhood factors. *Child Development*. 2014; 85(4):1433–1445. <https://doi.org/10.1111/cdev.12242>. [PubMed: 24779417]
- Holzman JB, Bridgett DJ. Heart rate variability indices as bio-markers of top-down self-regulatory mechanisms: A meta-analytic review. *Neuroscience and Biobehavioral Reviews*. 2017; 74:233–255. [PubMed: 28057463]
- Hughes C, Ensor R, Wilson A, Graham A. Tracking executive function across the transition to school: A latent variable approach. *Developmental Neuropsychology*. 2010; 35(1):20–36. <http://dx.doi.org/10.1080/87565640903325691>. [PubMed: 20390590]
- Jester JM, Nigg JT, Puttler LI, Long JC, Fitzgerald HE, Zucker RA. Intergenerational transmission of neuropsychological executive functioning. *Brain and Cognition*. 2009; 70:145–153. <http://dx.doi.org/10.1016/j.bandc.2009.01.005>. [PubMed: 19243871]
- Kane MJ, Engle RW. Working-memory capacity and the control of attention: The contributions of goal neglect, response competition, and task set to Stroop interference. *Journal of Experimental Psychology: General*. 2003; 132(1):47–70. <http://dx.doi.org/10.1037/0096-3445.132.1.47>. [PubMed: 12656297]
- Kim MH, Grammer JK, Marulis LM, Carrasco M, Morrison FJ, Gehring WJ. Early math and reading achievement are associated with the error positivity. *Developmental Cognitive Neuroscience*. 2016; 22:18–26. <http://dx.doi.org/10.1016/j.dcn.2016.09.002>. [PubMed: 27744098]
- Lengua LJ, Moran L, Zalewski M, Ruberry E, Kiff C, Thompson S. Relations of growth in effortful control to family income, cumulative risk, and adjustment in preschool-age children. *Journal of Abnormal Child Psychology*. 2015; 43:705–720. <http://dx.doi.org/10.1007/s10802-014-9941-2>. [PubMed: 25253079]
- Leve LD, DeGarmo DS, Bridgett DJ, Neiderhiser JM, Shaw DS, Harold GT, ... Reiss D. Using an adoption design to separate genetic, prenatal, and temperament influences on toddler executive function. *Developmental Psychology*. 2013; 49(6):1045–1057. <http://dx.doi.org/10.1037/a0029390>. [PubMed: 22799580]
- Luck SJ, Vogel EK. The capacity of visual working memory for features and conjunctions. *Nature*. 1997; 390:279–280. <http://dx.doi.org/10.1038/36846>. [PubMed: 9384378]

- Matthews JS, Ponitz CC, Morrison FJ. Early gender differences in self-regulation and academic achievement. *Journal of Educational Psychology*. 2009; 101(3):689–704. <http://dx.doi.org/10.1037/a0014240>.
- McClelland MM, Acock AC, Piccinin A, Rhea SA, Stallings MC. Relations between preschool attention span-persistence and age 25 educational outcomes. *Early Childhood Research Quarterly*. 2013; 28(2):314–324. <http://dx.doi.org/10.1016/j.ecresq.2012.07.008>. [PubMed: 23543916]
- McClelland MM, Cameron CE, Connor CM, Farris CL, Jewkes AM, Morrison FJ. Links between behavioral regulation and preschoolers' literacy, vocabulary, and math skills. *Developmental Psychology*. 2007; 43:947–959. <http://dx.doi.org/10.1037/0012-1649.43.4.947>. [PubMed: 17605527]
- McClelland, MM., Leve, LD., Pears, KC. Preschool executive functions in the context of family risk. In: Griffin, JA, McArdle, P., Freund, LS., editors. *Executive function in preschool-aged children*. Washington, DC: American Psychological Association; 2016. p. 241–257. <http://dx.doi.org/10.1037/14797-011>
- Miyake A, Friedman NP, Emerson MJ, Witzki AH, Howerter A, Wager TD. The unity and diversity of executive functions and their contributions to complex “Frontal Lobe” tasks: A latent variable analysis. *Cognitive Psychology*. 2000; 41(1):49–100. <http://dx.doi.org/10.1006/cogp.1999.0734>. [PubMed: 10945922]
- Moffitt TE, Arseneault L, Belsky D, Dickson N, Hancox RJ, Harrington H, Caspi A. A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences*. 2011; 108:2693–2698. <http://dx.doi.org/10.1073/pnas.1010076108>.
- Montroy JJ, Bowles RP, Skibbe LE, McClelland MM, Morrison FJ. The development of self-regulation across early childhood. *Developmental Psychology*. 2016; 52(11):1744–1762. <http://dx.doi.org/10.1037/dev0000159>. [PubMed: 27709999]
- Morasch, KC., Raj, V., Bell, MA. The development of cognitive control from infancy through childhood. In: Reisberg, D., editor. *Oxford handbook of cognitive psychology*. New York, NY: Oxford University Press; 2013. p. 989–999. <http://dx.doi.org/10.1093/oxfordhb/9780195376746.013.0062>
- Morrison, FJ., Grammer, JK. Conceptual clutter and measurement mayhem: Proposals for cross-disciplinary integration in conceptualizing and measuring executive function. In: Griffin, JA, McArdle, P., Freund, LS., editors. *Executive function in preschool-aged children*. Washington, DC: American Psychological Association; 2016. p. 327–348. <http://dx.doi.org/10.1037/14797-015>
- Nelson, JM., James, TD., Chevalier, N., Clark, CAC., Espy, KA. Structure, measurement, and development of preschool executive function. In: Griffin, JA, McArdle, P., Freund, LS., editors. *Executive function in preschool-aged children*. Washington, DC: American Psychological Association; 2016. p. 65–89. <http://dx.doi.org/10.1037/14797-004>
- Pollak SD, Klorman R, Thatcher JE, Cicchetti D. P3b reflects maltreated children's reactions to facial displays of emotion. *Psychophysiology*. 2001; 38(2):267–274. <http://dx.doi.org/10.1017/S0048577201990808>. [PubMed: 11347872]
- Rhoades BL, Greenberg MT, Lanza ST, Blair C. Demographic and familial predictors of early executive function development: Contribution of a person-centered perspective. *Journal of Experimental Child Psychology*. 2011; 108(3):638–662. <http://dx.doi.org/10.1016/j.jecp.2010.08.004>. [PubMed: 20828709]
- Roos LE, Kim HK, Schnabler S, Fisher PA. Children's executive function in a CPS-involved sample: Effects of cumulative adversity and specific types of adversity. *Children and Youth Services Review*. 2016; 71:2016.
- Roos LE, Pears K, Bruce J, Kim HK, Fisher PA. Impulsivity and the association between the feedback-related negativity and performance on an inhibitory control task in young at-risk children. *Psychophysiology*. 2015; 52(5):704–713. <http://dx.doi.org/10.1111/psyp.12389>. [PubMed: 25424570]
- Rose SA, Feldman JF, Jankowski JJ. Implications of infant cognition for executive functions at age 11. *Psychological Science*. 2012; 23(11):1345–1355. <http://dx.doi.org/10.1177/0956797612444902>. [PubMed: 23027882]

- Senn TE, Espy KA, Kaufmann PM. Using path analysis to understand executive function organization in preschool children. *Developmental Neuropsychology*. 2004; 26(1):445–464. http://dx.doi.org/10.1207/s15326942dn2601_5. [PubMed: 15276904]
- Schmeichel BJ, Volokhov RN, Demaree HA. Working memory capacity and the self-regulation of emotional expression and experience. *Journal of Personality and Social Psychology*. 2008; 95(6): 1526–1540. <http://dx.doi.org/10.1037/a0013345>. [PubMed: 19025300]
- Simmering VR. I. Working memory capacity in context: Modeling dynamic processes of behavior, memory, and development. *Monographs of the Society for Research in Child Development*. 2017; 81(3):7–24. <http://dx.doi.org/10.1111/mono.12249>.
- St Clair-Thompson HL, Gathercole SE. Executive functions and achievements in school: Shifting, updating, inhibition, and working memory. *The Quarterly Journal of Experimental Psychology*. 2006; 59(4):745–759. <http://dx.doi.org/10.1080/17470210500162854>. [PubMed: 16707360]
- Sturge-Apple ML, Suor JH, Skibo MA. Maternal child-centered attributions and harsh discipline: The moderating role of maternal working memory across socioeconomic contexts. *Journal of Family Psychology*. 2014; 28(5):645–654. <http://dx.doi.org/10.1037/fam0000023>. [PubMed: 25221969]
- Tangney JP, Baumeister RF, Boone AL. High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of Personality*. 2004; 72(2):271–324. <http://dx.doi.org/10.1111/j.0022-3506.2004.00263.x>. [PubMed: 15016066]
- Thompson RA, Calkins SD. The double-edged sword: Emotion regulation in high risk children. *Development and Psychopathology*. 1996; 8:163–182. <http://dx.doi.org/10.1017/S0954579400007021>.
- Vogel EK, Woodman GF, Luck SJ. Storage of features, conjunctions, and objects in visual working memory. *Journal of Experimental Psychology: Human Perception and Performance*. 2001; 27:92–114. <http://dx.doi.org/10.1037/0096-1523.27.1.92>. [PubMed: 11248943]
- Wiebe SA, Espy KA, Charak D. Using confirmatory factor analysis to understand executive control in preschool children: I. Latent structure. *Developmental Psychology*. 2008; 44(2):575–587. <http://dx.doi.org/10.1037/0012-1649.44.2.575>. [PubMed: 18331145]
- Wiebe SA, Sheffield TD, Espy KA. Separating the fish from the sharks: A longitudinal study of preschool response inhibition. *Child Development*. 2012; 83(4):1245–1261. <http://dx.doi.org/10.1111/j.1467-8624.2012.01765.x>. [PubMed: 22533453]
- Wiebe SA, Sheffield T, Nelson JM, Clark CAC, Chevalier N, Espy KA. The structure of executive function in 3-year-olds. *Journal of Experimental Child Psychology*. 2011; 108:436–452. <http://dx.doi.org/10.1016/j.jecp.2010.08.008>. [PubMed: 20884004]
- Wigfield A, Eccles JS. Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*. 2000; 25(1):68–81. <http://dx.doi.org/10.1006/ceps.1999.1015>. [PubMed: 10620382]
- Wigfield, A., Eccles, JS., Schiefele, U., Roeser, RW., Davis-Kean, PE. Development of achievement motivation. In: Damon, W., Eisenberg, N., editors. *Handbook of child psychology*. 6th. Vol. 3. New York, NY: Wiley; 2006. p. 933–1002.

Highlights

- Maternal and child EF were explored in a sample characterized by risk and adversity
- Higher maternal WM was related to better Go/No-Go child accuracy and slower RT
- Maternal WM was unrelated to child accuracy and RT on an emotional Go/No-Go task

Table 1

Descriptive statistics for maternal and child EF measures

VARIABLES	Mean	SD	Min	Max
Maternal WM capacity	2.71	0.38	1.82	3.42
Child EF measures				
Fish/Shark GNG: Go accuracy	0.70	0.26	0.07	0.97
Fish/Shark GNG: No-Go accuracy	0.18	0.19	0.00	0.70
Fish/Shark GNG: d'	1.61	1.02	-0.27	3.48
Fish/Shark GNG: Reaction time	687.94	105.93	284.33	973.50
Emotional GNG: Go accuracy (Angry)	0.67	0.24	0.12	1.00
Emotional GNG: Go accuracy (Happy)	0.72	0.27	0.12	1.00
Emotional GNG: No-Go accuracy (Angry)	0.22	0.18	0.00	0.76
Emotional GNG: No-Go accuracy (Happy)	0.25	0.17	0.00	0.62
Emotional GNG: d' (Angry)	1.43	0.88	-0.79	2.60
Emotional GNG: d' (Happy)	1.59	1.14	-0.62	3.56
Emotional GNG: Reaction time (Angry)	929.01	136.05	675.56	1225.40
Emotional GNG: Reaction time (Happy)	943.49	175.33	476.33	1319.00

Note. Statistics represent 38 mother-child dyads for which complete data were available. Accuracy is expressed as a number between 0 and 1. Go accuracy reflects correct responses on Go trials (hit rate). No-Go accuracy reflects incorrect responses on No Go trials (false alarm rate). d' equals hit rate minus false alarm rate in standard units. Reaction time reflects correct responses on Go trials and is measured in milliseconds.

Table 2

Bivariate correlations for maternal and child EF variables

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Child age	1.00															
2. Child gender ^a	.10	1.00														
3. Maternal education ^b	-.15	.19	1.00													
4. Maternal WM capacity	-.19	-.15	-.10	1.00												
5. Fish/Shark GNG: Go accuracy	.64***	-.12	-.46**	.20	1.00											
6. Fish/Shark GNG: No-Go accuracy	-.17	-.32*	-.07	.01	.10	1.00										
7. Fish/Shark GNG: <i>d'</i>	.66***	.09	-.36*	.10	.78***	-.52***	1.00									
8. Fish/Shark GNG: Reaction time	-.18	-.16	-.03	.37*	-.18	-.21	-.05	1.00								
9. Emotional GNG: Go accuracy (Angry)	.65***	.02	-.19	-.06	.56***	.08	.42**	-.16	1.00							
10. Emotional GNG: Go accuracy (Happy)	.62***	.12	-.31 ⁺	.11	.65***	.08	.49**	-.18	.68***	1.00						
11. Emotional GNG: No-Go accuracy (Angry)	-.01	-.22	-.05	.06	.11	.43**	-.15	-.06	.14	.07	1.00					
12. Emotional GNG: No-Go accuracy (Happy)	-.11	-.35*	-.18	-.04	-.01	.54***	-.34*	.04	-.09	-.00	.26	1.00				
13. Emotional GNG: <i>d'</i> (Angry)	.53***	.16	-.13	-.09	.38*	-.21	.45**	-.10	.70***	.50**	-.58***	-.23	1.00			
14. Emotional GNG: <i>d'</i> (Happy)	.55***	.34*	-.13	.12	.51**	-.26	.58***	-.18	.56***	.79***	-.10	-.60***	.50**	1.00		
15. Emotional GNG: Reaction time (Angry)	-.09	-.01	.09	.12	-.07	-.12	-.00	.40*	-.11	-.22	-.39*	-.13	.17	-.14	1.00	
16. Emotional GNG: Reaction time (Happy)	.00	-.12	-.04	-.04	-.10	-.25	.07	.31 ⁺	.14	-.19	-.24	-.41**	.27 ⁺	.05	.67***	1.00

Note.

*** p<0.001,

** p<0.01,

* p<0.05,

⁺ p<0.10. Listwise deletion of missing values. Correlations represent 38 mother-child dyads.^a Male = 0, Female = 1^b HS diploma or less = 0, Post-HS education = 1

Table 3

OLS regression estimates of maternal WM capacity on child EF on the Fish/Shark Go/No-Go task

VARIABLES	(1) Child Go accuracy	(2) Child No-Go accuracy	(3) Child d'	(4) Child RT (Go trials)
Child gender ^a	-0.044 (0.056)	-0.114 ⁺ (0.0620)	0.215 (0.244)	-20.92 (34.67)
Child age	0.195 ^{***} (0.033)	-0.0336 (0.0365)	0.768 ^{***} (0.144)	-13.45 (20.40)
Maternal education ^b	-0.162 ^{**} (0.057)	-0.0146 (0.0634)	-0.544 [*] (0.250)	0.11 (35.48)
Maternal WM capacity	0.190 [*] (0.074)	-0.0325 (0.0821)	0.574 ⁺ (0.324)	92.67 ⁺ (45.91)
Observations	38	38	38	38
R-squared	0.631	0.127	0.553	0.159

Note.

^{***}
p<0.001,^{**}
p<0.01,^{*}
p<0.05,⁺
p<0.10^aMale = 0, Female = 1^bHS diploma or less = 0, Post-HS education = 1

OLS regression estimates of maternal WM capacity on child EF on the Emotional Go/No-Go task

Table 4

VARIABLES	(1) Child Go accuracy (Angry)	(2) Child Go accuracy (Happy)	(3) Child No-Go accuracy (Angry)	(4) Child No-Go accuracy (Happy)	(5) Child d' (Angry)	(6) Child d' (Happy)	(7) Child RT Go trials (Angry)	(8) Child RT Go trials (Happy)
Child gender ^a	-0.010 (0.063)	0.068 (0.068)	-0.0768 (0.0634)	-0.109 ⁺ (0.0552)	0.0681 (0.206)	0.713 [*] (0.306)	0.69 (47.90)	-45.05 (61.99)
Child age	0.179 ^{***} (0.037)	0.190 ^{***} (0.040)	0.00247 (0.0373)	-0.0241 (0.0325)	0.468 ^{**} (0.121)	0.577 ^{**} (0.182)	-9.17 (28.18)	-0.05 (36.47)
Maternal education ^b	-0.038 (0.065)	-0.116 (0.070)	-0.00109 (0.0649)	-0.0520 (0.0565)	-0.209 (0.208)	-0.0341 (0.314)	24.20 (49.01)	-7.31 (63.43)
Maternal WM capacity	0.034 (0.084)	0.159 ⁺ (0.091)	0.0120 (0.0840)	-0.0582 (0.0731)	0.149 (0.265)	0.893 [*] (0.393)	42.81 (63.42)	-27.85 (82.09)
Observations	38	38	38	38	35	35	38	38
R-squared	0.438	0.485	0.047	0.159	0.376	0.387	0.028	0.019

Note.

p<0.001,

**
p<0.01,

*
p<0.05,

⁺ p<0.10. Children with d' values less than or equal to 0 were excluded from the analysis.

^a Male = 0, Female = 1

^b HS diploma or less = 0, Post-HS education = 1