For better or for worse?

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DOI:
10.1111/cdev.12915

For Better or for Worse? Positive and Negative Parental Influences on Young Children's Executive Function.

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Abstract

Despite rapidly growing research on parental influences on children's executive function (EF), the uniqueness and specificity of parental predictors and links between adult EF and parenting remain unexamined. This 13-month longitudinal study of 117 parent-child dyads (60 boys; *M* Age at Time 1 = 3.94 years, *SD* = 0.53) included detailed observational coding of parent-child interactions and assessed adult and child EF and child verbal ability (VA). Supporting a differentiated view of parental influence, negative parent-child interactions and parental scaffolding showed unique and specific associations with child EF, while the home learning environment and parental language measures showed global associations with children's EF and VA.

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Research on executive function (EF) is rooted in both cognitive and clinical psychology. From a cognitive perspective, the term EF encompasses the higher-order processes that underpin both goal-directed action and adaptive responses to novel, complex or ambiguous situations (Hughes, Graham, & Grayson, 2005). Clinically, EF is used to describe the functions of the prefrontal cortex (PFC), which differs from other brain regions in several respects including protracted maturation extending well into adolescence (Kolb et al., 2012). Measurements of EF typically centre on three related abilities: (1) 'inhibitory control' or the ability to override entrenched habits or impulses; (2) 'working memory' or the ability to update information held in mind; and (3) 'set shifting' or the ability to switch easily between tasks (Garon, Bryson & Smith, 2008; Miyake & Friedman, 2012). In adolescence and adulthood these abilities appear to be correlated but separable (Miyake & Friedman, 2012). In early childhood however, individual differences in performance on a range of measures of EF can be explained by a single latent factor (Wiebe et al., 2008). The explosion of interest in EF in childhood over the past two decades reflects, at least in part, the recognition that individual differences in EF underpin a range of important developmental outcomes. Preschool children with advanced EF show better social understanding (e.g., Devine & Hughes, 2014), superior academic ability (Devine, Bignardi & Hughes, 2016) and fewer behavioral problems (e.g., Hughes & Ensor, 2008). Understanding the origins of individual differences in EF is therefore an important goal for developmental science.

Twin research highlights the potential importance of genetic influences on individual differences in EF (e.g., Miyake & Friedman, 2012). Addressing this possibility, several recent studies have investigated the intergenerational association in EF, with mixed results. Specifically, in a study of 361 adopted 27-month-old children, Leve et al. (2013) found no evidence for a correlation between children's EF and individual differences their biological parents' performance on a conflict inhibition task. In contrast, Hughes & Ensor (2009) reported a moderate correlation between parental planning and 4-year-old children's EF that persisted even when individual differences in verbal ability and age 2 EF were taken into account. In two papers based on a study of 62 children across three time points (ages 2, 3 and 4), Cuevas and colleagues (Cuevas, Deater-Deckard, Kim-Spoon, Wang, Morasch, & Bell, 2014; Cuevas, Deater-Deckard, Kim-Spoon, Watson, Morasch, & Bell, 2014) also reported a moderate and significant association between parental EF and individual differences in children's EF at ages 2, 3 and 4. These cross-sectional associations held even when individual differences in children's family background, age and verbal ability were taken into account. However, when effects of prior levels of child EF and observed parental sensitivity were controlled, parental EF did not make a unique contribution to children's EF at age 4.

Although it is difficult to tease apart effects of nature and nurture without a genetically sensitive design (e.g., adoption study), there are guiding principles that emerge from research on behavioral genetics. For example, two of the 'big ideas' offered by Asbury and Plomin (2014) in their review of the literature on genetic influences on education, are that: (1) genetic factors underpin temporal continuity while environmental factors contribute to change over time; (2) genes are generalists (e.g., the same genes contribute to individual differences in both anxiety and depression – Eley & Stevenson, 1999) and environments are specialists (i.e., people with the same genetic susceptibility to anxiety or depression may manifest very different symptoms, depending on the nature of environmental adversity experienced). Each of these conclusions leads to a testable hypothesis. For example, in line with the 'genes are generalists' view, one would expect parent EF to be correlated with a range of child cognitive abilities (e.g., both EF and verbal ability); in turn, this leads to the hypothesis that the intergenerational association in EF would be attenuated once other more general aspects of children's cognitive ability are controlled. Second, if genetic factors underpin stability in any given trait, controlling for children's prior EF ability should attenuate any genetically mediated association between parent and child EF.

In contrast with the genetic perspective outlined above, a growing body of research indicates that the development of EF, like language, but unlike many other neuro-cognitive functions, is particularly susceptible to environmental influence (Noble, Norman, & Farah, 2005). For example, EF in childhood is robustly associated with variation in socio-economic status (Ursache & Noble, 2016) and impaired in post-institutionalized children (Merz, Harlé, Noble, & McCall, 2016). Likewise, longitudinal research using latent growth models has demonstrated that both early exposure to maternal symptoms of depression and persistence of depressive symptoms show unique associations with delays in children's EF between the ages of 2 and 6 (Hughes, Roman, Hart, & Ensor, 2013). In short, research evidence suggests that families can both help and hinder preschool children's developing EF skills: socio-cultural accounts of cognitive development emphasize the benefits of support from more expert social partners (e.g., Vygotsky, 1978), while clinical research evidence highlights the adverse effects of stressful environments on neurocognitive development (e.g., Blair & Raver, 2015).

Historically, these two perspectives have been adopted by different research groups such that that these distinct accounts have yet to be integrated to examine positive and negative parental predictors of preschool children's EF in tandem. This is a notable omission given the growing evidence for specific links between different parental characteristics and specific child outcomes (e.g., Smetana, 2017). In this 'domains' approach, socialization is viewed not as a general process but as a collection of distinct processes that act on specific domains of development (Davidov, 2013). Adopting this differentiated view of parental influence (Grusec & Davidov, 2010), the current study aimed to integrate clinical and socio-cultural accounts by examining the uniqueness and overlap of both positive and negative parental influences on individual differences in EF in a longitudinal study of 117 preschool children and their parents.

Do Both Positive and Negative Dimensions of Parental Behavior Influence Young Children's EF?

While evidence from large-scale longitudinal studies demonstrates that parental sensitivity predicts developmental gains in EF (Blair, Raver, & Berry, 2014), findings from two more detailed studies highlight the likelihood that multiple independent processes contribute to the association between family environment quality and young children's EF. Specifically, Hughes and Ensor (2009) found that gains in EF between the ages of 2 and 4 showed independent associations (in the expected directions) with family chaos, the richness of parental language, verbal scaffolding (as measured using a global rating of parental praise, elaboration and encouragement) and parental EF. Likewise, Bernier, Carlson and Whipple (2010) showed that measures of maternal sensitivity, mind-mindedness and autonomy support (a global rating of parental support and flexibility during structured play) gathered at 12 to 15 months each correlated with child EF at 26 months. Moreover autonomy support predicted EF at 26 months even when individual differences in early cognitive ability were taken into account. Importantly, while the two studies above were unusual in including measures of parental scaffolding, sensitivity and support, neither incorporated explicit measures of children's responses to parents' interventions. This is a notable omission for at least two reasons. First, in a review of the efficacy of a wide variety of school-based interventions designed to promote EF development, Diamond and Lee (2011) noted that a carefully monitored progression in level of difficulty or challenge was one of the key ingredients for success. Second, Wood and colleagues' original and seminal research on mothers' tutoring strategies (Wood, Bruner, & Ross, 1976; Wood & Middleton, 1975) showed that effective 'scaffolding' hinges upon the parent's ability to modify their level of support in a way that is contingent upon children's difficulty or success on the task.

This process of 'contingent shifting' (Wood et al., 1976) involves the parent (or expert partner) following a contingency rule, altering the specificity of instruction to provide direct instruction when needed while gradually transferring responsibility as the child shows increasing task mastery. In other words, research on scaffolding suggests that alongside attention, warmth, stimulation and encouragement, parents also need to demonstrate flexibility in order to promote children's goal-directed activities. The ability to be flexible in feedback in order to follow the contingency rule has, as one might expect, been found to be higher in parents rated as authoritative (e.g., Pratt, Green, MacVicar, & Bountrogianni, 1992) or sensitive (Mulvaney, McCartney, Bub, & Marshall, 2006). Underscoring the importance of parent-child contingency, studies incorporating measures of parent-child contingency during problem-solving tasks demonstrate that individual differences in parental scaffolding show longitudinal relations with children's EF (Hammond, Muller, Carpendale, Bibok, & Lieberman-Finestone, 2012).

Broadly speaking, existing studies have shown that individual differences in children's EF are related to both the quality and quantity of affective and cognitive support that parents provide. However, as noted in a recent review of research on parental influences on young children's EF (Fay-Stammbach, Hawes & Meredith, 2014), it is unclear whether these different aspects of parental support show independent or overlapping associations with child EF. Thus in the current study we included several different direct observational ratings of parental behavior. Integrating the socio-cultural and clinical traditions, we included quantitative measures of family learning support alongside direct measures of the cognitive and affective quality of parent-child interactions to investigate the unique relations between these distinct aspects of parental behavior and children's EF. We predicted that parental scaffolding (as measured by contingent shifting) and negative parent-child interactions (i.e., interactions characterized by negative affect and parental control) would exhibit unique and opposing associations with variation in children’s EF.

Do Parental Influences on Children’s EF Overlap with Parental Influences on other Cognitive Abilities?

With very few exceptions (e.g., Hughes & Ensor, 2009), previous studies have not reported on the specificity of parental influences on EF. Do parental behaviors, such as scaffolding, contribute to variation in EF in particular or to children’s cognitive skills more generally? Answering this question is crucial to adopting a ‘domains’ approach to the socialization of EF (e.g., Davidov, 2013). We therefore examined the relations between each of the parental behaviors in our study and growth in children’s verbal ability. Verbal ability, like EF, is known to be related to a range of parental factors, such as socio-economic status and early parent-child interactions (Hoff, 2006). One possibility, discussed in Devine, Bignardi and Hughes (2016), is that there are domain-general effects of parental cognitive support on both EF and verbal ability. For example, developmental associations have been reported between parental scaffolding and children’s later academic success and adjustment (e.g., Pratt, Green, MacVicar, & Bountrogianni, 1992). Equally, the provision of informal learning opportunities (or the ‘Home Learning Environment’), a well-recognized predictor of children’s language skills (e.g., Son & Morrison, 2010), might also be expected to provide a training ground for children’s developing EF. For example, as noted by Blair and Raver (2015), reading activities require children to shift their attention between phonemes and whole words. Likewise, the richness of children’s linguistic environments is known to predict variation in children’s language skills (e.g., Hoff, 2006) and so may indirectly foster the development of children’s EF. On the other hand, there might also be domain general effects of parental affective support. For example, parent-child interactions characterized by conflict and control have been shown to impact on children's language development (MacKenzie, Nicklas, Waldfogel & Brooks-Gunn, 2012). The domain-general account-leads to the prediction that each aspect of parental behavior will be of similar importance for both children's EF and VA. In contrast, a domain-specific account predicts that there will be particular aspects of parenting that are differentially salient for either child EF or child VA. More specifically, while both parental scaffolding (as measured by contingent shifting) and negative parent-child interactions (i.e., interactions characterized by negative affect and parental control) are hypothesized to exhibit unique associations with variation in children's EF, parental language input is hypothesized to be specifically related to individual differences in children's verbal ability. Identifying what aspects of parental behavior shape individual differences in EF (and not both EF and VA) will shed light on the potential developmental mechanisms involved in the socialization of EF.

Summary of Study Aims

Overall then, the evidence from existing research suggests that individual differences in preschoolers' EF are associated with variations in: parental EF, parental cognitive support (e.g., scaffolding or 'contingent shifting'); the affective quality of parent-child interactions (e.g., negative parent-child interactions); and more general features of the family environment (e.g., parental language input and home learning opportunities). Unlike previous studies, the current investigation encompasses each of these potential parental influences upon EF development in the preschool years. In addition, by conducting parallel analyses with EF and VA as outcome variables, we aimed to assess the specificity of parental influences on each cognitive domain. In sum, this study had two primary goals: (1) to unite previously disparate bodies of research by studying both positive and negative parental influences on children's EF in order to establish whether individual parental measures show unique or overlapping associations with child EF; and (2) to conduct parallel analyses with child VA as the outcome, in order to assess the specificity of parental influences on child EF.

Method

Participants

Participants were recruited from nurseries, shopping centres and playgroups in the East of England. Children had to be aged either 3 or 4 years old without a history of developmental delay and be native English speakers. One hundred twenty parent-child dyads took part at Time 1as part of a larger international study of children's socio-cognitive development (Hughes, Devine & Wang, 2017). One hundred seventeen dyads (60 boys) agreed to be contacted for a follow-up study (3 families planned to leave the region). Families were socio-economically homogenous (81% of parents had a degree level education) but ethnically diverse (66% White British). Of the 117 families contacted at Time 2, two were no longer eligible to participate as they had left the country. Of the eligible 115 families, 103 (90%) took part at Time 2 approximately 13 months later, SD = 1.65 months, range: 11 - 17 months. At Time 1 children were aged 3.94 years, SD = 0.53, range: 3 – 4.95 years, and at Time 2 children were aged 5.11 years, SD = 0.54, range: 4 – 6.10 years. Non-returners did not differ from those who returned for the second visit in age, gender or general cognitive ability, but were marginally more likely to have low levels of parental education, OR = 3.05, B = 1.12, SE = 0.64, p = .08.

Procedures

The University Research Ethics Committee approved all procedures prior to commencement of the study. Parents and children participated in two laboratory visits lasting up to 75 minutes approximately 1 year apart. Children completed tasks designed to measure EF and general cognitive ability. Individual child cognitive testing lasted approximately 30 minutes. Child completed the task battery in a fixed counter-balanced format such that no two tasks from any domain (e.g., verbal ability, EF) were completed in succession. Children were allowed rest breaks and received stickers for completing each task. Parents completed a questionnaire booklet and computerized EF tasks in another room while children underwent cognitive testing. Parents were then observed interacting with their child during 5 minutes of structured play with a set of jigsaw puzzles and 5 minutes of free play. Parents were debriefed and provided with £15 and a small gift for their child. Children completed three measures of EF at both Time 1 and 2. Two additional tasks were administered at Time 2. The DCCS Border Game was not included at Time 1 because pilot work indicated that the youngest children would find the task too difficult and the Day/Night Stroop was not included at Time 1 to minimize problems of fatigue. Adding these two tasks to the EF battery when the children were older and able to concentrate for a longer period had the additional advantage of providing sufficient time for a second researcher to administer a parallel parent EF battery at Time 2.

Measures

Child EF. Children completed a short battery of tasks designed to measure individual differences in EF at Time 1 (March – September, 2013) and 2 (March – September 2014). These represent widely-used and valid measures of EF in early childhood (Garon, Bryson & Smith, 2008). The children completed the *Happy-Sad Stroop* (Lagattuta, Sayfan, & Monsour, 2011) at both time points as a measure of conflict inhibition. Children were shown two 8cm x 8cm cards depicting either a yellow 'happy face' or a yellow 'sad face'. Children were asked to point to the happy face and then to the sad face. The examiner then told the children that they would play a 'silly game' so that when the examiner said 'happy' the child had to point to the sad face and when the examiner said 'sad' the child had to point to the happy face. Children completed 4 training trials with feedback from the examiner and received up to two further sets of 4 training trials if any errors were made. If unsuccessful on training trials, children were assigned a score of 0 and testing was discontinued. In the test phase of the task the children completed 20 trials in a fixed pseudo-random order with no feedback. The number of correct items was summed together.

Children completed the *Dimension Change Card Sort* (DCCS) Task (Zelazo, 2006) at both Time 1 and 2 as a measure of their ability to switch flexibly between rules. In each phase the children were shown two 10cm x 7.5cm target cards (one showing a blue rabbit and the other a red boat) attached to two sorting boxes and were required to sort six cards depicting either a blue boat or red rabbit. The pre-switch phase consisted of either six trials of the 'color game' (i.e., matching the sorting card to the color of the target card) or six trials of the 'shape game' (i.e., matching the sorting card to the shape depicted on the target card) (counter-balanced across participants). All children passed the pre-switch phase (i.e., sorted 5 or more cards correctly) and those children playing the color game proceeded to the shape game and *vice versa*. In the post-switch phase the children were told that the rules had changed and proceeded to either the shape game or color game depending on what game they had completed in the pre-switch phase. Children were awarded 1 point for each correctly sorted card in the post-switch phase. At Time 2 children passing the post-switch phase (i.e., sorted 5 or more cards correctly) completed the border game. In the border game children sorted a further 12 cards containing 6 normal sorting cards and 6 cards with a thick black border. Children sorted the normal cards according to one rule (e.g., shape game) and the black border cards according to another (e.g., color game) receiving 1 point for each correctly sorted card. Children who failed the post-switch phase received 0 on the border game.

Children completed the *Self-Ordered Pointing Task* (Cragg & Nation, 2007) at Time 1 and 2 as a measure of working memory. Children were shown a color flipbook with an increasing number of pictures of single syllable objects (ranging from 2 objects to 7 objects with two sets in each number) in one of 16 locations on the page. For example, the first page depicted two images (e.g., bowl, flag) and the second page depicted the same images but in different spatial locations. No two objects were taken from the same class of objects (e.g., fruits, toys, pets). Children were required to point to a new picture on each page and could not select the same picture twice. The task began with two demonstration sets (with experimenter feedback). Repetition errors (i.e., repeated points to the same picture) were recorded and used as an index of working memory. These scores were reflected for consistency with other measures of EF in the study (i.e., high scores indicated greater EF).

Children also completed the *Day/Night Stroop* (Gerstadt, Hong, & Diamond, 1994) at Time 2 to measure of conflict inhibition. This task followed the same procedure as the Happy-Sad Stroop using two 10cm x 7.5cm cards depicting either the sun or the moon instead of cards depicting happy and sad faces. Children pointed to the picture of the sun when the examiner said 'night' and to the picture of the moon when the examiner said 'day'. Children completed 20 trials in a fixed order receiving 1 point for each correct trial.

Child Cognitive and Language Ability. Children completed two tasks from the Wechsler Preschool and Primary Scale of Intelligence (WPPSI-III-UK) (Rust, 2003). Children completed the Object Assembly task at Time 1to measure *General Cognitive Ability (IQ)*. After two training trials in which the examiner demonstrated how to use the puzzle pieces, children assembled a set of two-dimensional puzzles depicting cartoon images of objects (e.g., clock, bird). The number of correctly aligned junctures in the first 90s of trial was recorded. The children completed up to 14 trials and scores from each trial were summed together. Testing was discontinued if children scored 0 on three consecutive trials. The Object Assembly task is strongly correlated with Full Scale and Performance Intelligence Quotient in young children and shows excellent test-retest reliability (Wechsler, 2002). Children completed the Receptive Vocabulary task at Time 1 and 2 to measure *Verbal Ability*. Children were asked to point to a picture shown in a color flipbook depicting 4 images on each page that matched a word uttered by the examiner. Children received 1 point for each correctly identified picture and testing was discontinued if children made 5 consecutive errors. Children completed up to 38 trials and scores from each item were summed together. The Receptive Vocabulary subscale of the WPPSI shows excellent test-retest reliability and is strongly correlated with Verbal Intelligence Quotient in young children and so provides a valid index of children's verbal ability (Wechsler, 2002).

Negative Parent-Child Interaction, Scaffolding and the Home Learning Environment. Parents and children were recorded at Time 1 for 5 minutes playing together using wall-mounted digital cameras. Parents and children were provided with three jigsaw puzzles (a 6-, 8- and 12-piece puzzle) from the Galt Velvet Puzzles Jigsaw set. Parents were asked to work with their child to complete as many of the three puzzles as possible within 5 minutes. The task was based on procedures used in previous studies of individual differences in parent-child interactions and parental scaffolding (e.g., Carr & Pike, 2012). Observed parental behaviors in similar tasks show stability over time and across contexts (e.g., Hughes & Ensor, 2007). The data from these videos were then coded off-line using two different coding schemes by different trained researchers naive to the participants' test scores.

Negative Parent-Child Interaction was assessed using the Parent-Child Interaction System (PARCHISY) coding scheme (Deater-Deckard, Pylas, & Petrill, 1997). Parents received scores on three 7-point rating scales (ranging from 'none' to 'exclusive/constant'): negative control (i.e., use of physical control, use of criticism), negative affect (i.e., frowning, harsh tone of voice) and conflict (i.e., disagreement, arguing or tussling). Double coding of 25 randomly selected videos showed acceptable intra-class correlations for each item: negative content ICC = .89, negative affect ICC = .75, and conflict ICC = .74. The remaining clips were double-coded and scores were averaged across raters.

We measured *Parental Scaffolding* using a coding scheme devised by Wood and Middleton (1975) and later revised by Meins (1997). Each verbal and non-verbal task-related behavior was rated by coders naïve to parents' scores on Negative Parent-Child Interaction. We assigned parental behaviors into one of five mutually exclusive categories: Level 1 Orienting Verbal Suggestions (e.g., 'Let's start with the corners'); Level 2 Suggestions about Specific Pieces or Locations or Actions (e.g., 'Try turn that piece around'); Level 3 Verbal Solutions (e.g., 'This piece goes here'); Level 4 Direct Physical Solutions (e.g., Caregiver hands child a piece for a specific location); Level 5 Physical Demonstrations (e.g., Caregiver assembles or dismantles parts of the puzzle) (Devine, Bignardi & Hughes, 2016). We coded children's responses as either a 'success' (i.e., correct placement of the puzzle piece) or a 'failure' (i.e., incorrect placement of the piece). ICCs derived from 25 randomly selected double-coded videos, were acceptable for all codes: Level 1 intervention frequency ICC = .64, Level 2 intervention frequency ICC = .85, Level 3 intervention frequency ICC = .97, Level 4 intervention frequency ICC = .98, Level 5 intervention frequency ICC = .96, frequency of child successes ICC = .99 and frequency of child failures ICC = .94. The relatively low level of inter-rater agreement for the Level 1 interventions was accounted for by two cases where the two raters differed by more than 2. Removal of these cases increased the ICC to .87.

We organised parent-child codes into three-turn chains of parent interventions, child actions and parent responses. Where numerous interventions preceded a child action we selected the highest level of intervention (Carr & Pike, 2012;Wood & Middleton, 1975). We used these three-turn chains to assess the contingency between parents and children during the activity. We recorded the amount of times that parents shifted 'up' (i.e., moving from a less specific to more directive intervention level), shifted 'down' (i.e., moving from directive to less specific intervention level) and remained at the same level of intervention ('no shift') after each child response. Parental scaffolding was measured through parents' use of the contingency rule (Carr & Pike, 2012; Meins, 1997; Wood & Middleton, 1975), whereby a child's success should be followed by an intervention at the same or at a lower level of specificity and a child's failure should be followed by an intervention that is one or two levels higher than the previous level of intervention. We calculated contingency or scaffolding scores by summing the total number of times that parents used the contingency rule and dividing this by the total number of parental interventions after each success or failure.

At Time 2 parents completed *Home Learning Environment* (HLE) Index (Melhuish et al., 2008). Parents reported on the frequency with which they engaged in seven activities with their children (e.g., reading at home, teaching numbers and counting) on a 7-point scale (ranging from 'occasionally or less than once a week' to '7 times a week/constantly'). Parents received a score of 0 if they did not engage in a particular activity with their child. Internal consistency of this measure was acceptable ($\alpha = 0.73$) and so the scores from each item were summed together.

Parent Language Input and EF. *Parental Mean Length of Utterance (MLU)* was measured using verbatim transcripts of parent-child talk during 5-minutes of free play at Time 1 to provide an index of parental language input. Parents and children were recorded for 5 minutes playing together using wall-mounted unobtrusive digital cameras while the experimenters were in another room. Parents and children were provided with the Hasbro Play-Doh Sweets Lunchbox play set and instructed to play together as they normally would. Measures of parent-child talk during such observations are highly stable across time and across different observational contexts (Ensor, Devine, Marks & Hughes, 2014). The recordings were transcribed verbatim and analysed using Linguistic Enquiry and Word Count (LIWC) software (Tausczik & Pennebaker, 2010) to ascertain the parents' mean length of utterance by dividing the total number of words spoken by the total number of parental utterances during the 5-minute observation. We manually coded 25% of the transcripts from these interactions and found high levels of inter-rater reliability between a human coder and the LIWC software, ICC = .93.

Parental EF was measured using two computerized tasks at Time 2 based on tests designed by Davidson, Amso, Anderson, and Diamond (2006) to measure simple inhibition and task switching. In the Arrows Task (designed to measure inhibition) parents viewed one of four images of a purple arrow on a white screen. The arrow pointed either directly downward or diagonally on either the left- or right-hand side of the screen. During the congruent (control) trials, the arrow pointed directly downward and participants had to press the button on the same side as where the arrow appeared. During the incongruent (test) trails, the arrow pointed diagonally and participants had to press the button on the opposite side to where the arrow appeared. Before beginning participants received detailed instructions and practice items. Each 750-*ms* trial was preceded by a 250-*ms* interval in which a 16-point font black crosshair was displayed against a white background. Participants had to respond with a button press within the trial period to each of 20 control trials and 20 test trials administered in a random order. Efficiency scores were based on the total number of incongruent trials divided by the total time taken on incongruent trials. In line with previous studies anticipatory responses (<200ms) and missed responses were recorded as errors (Davidson et al., 2006).

The Hearts and Flowers test (designed to measure task switching) consisted of three separate tasks. Each task consisted of 20 trials in which one of two pictures (a red heart or red flower) was presented for 750-*ms* on either the left- or right-hand side of a white screen. Each trial was preceded by a 250-*ms* interval in which a black cross-hair was presented centrally on a white screen. In the congruent condition parents had to respond as quickly as possible by hitting a button on the same side as the red heart. In the incongruent condition parents had to respond as quickly as possible by hitting a button on the opposite side to where the red flower appeared. In the final mixed condition parents were had to press a button on the same side when a heart appeared and on the opposite side when a flower appeared. Parents completed each condition in a fixed order but trials within each condition were presented in a random order. Efficiency scores were calculated for the mixed condition by dividing the total number of correct responses by the total time taken on mixed trials. In line with previous studies anticipatory responses (<200*ms*) and missed responses were recorded as errors (Davidson et al., 2006).

Results

Analytic Strategy

We conducted our analyses in *MPlus* Version 7 (Muthèn & Muthèn, 2012) using a robust maximum likelihood estimator which is appropriate when data are non-normally distributed data and sample sizes are small (Brown, 2015). We used a full information approach to data analysis so that all cases with data at Time 1 were included in the analyses. Missing values were estimated in *MPlus* using the robust maximum likelihood estimator. This provides reliable estimates of missing values based on participants' scores on other variables in the model (Asparouhov & Muthen, 2010). For our primary analyses we used an auto-regressive structural equation model to examine the relations between parental measures and children's EF and verbal ability (VA) at Time 2. In auto-regressive models the dependent variable (X_2) is regressed onto an earlier measure of that same variable (X_1) and the predictor variables of interest (Y_1) (Hertzog & Nesselroade, 2003; Menard, 2002). The predictor variable (Y_1) is said to have a lagged or distal effect on the dependent variable (X_2) if it shows a significant association with the dependent variable when earlier scores on the dependent variable (X_1) are taken into account (Menard, 2002). We used Brown's (2015) four criteria to evaluate model fit: a non-significant χ^2 test of model fit, comparative fit index

(CFI) ≥ 0.95, Tucker Lewis index (TLI) ≥ 0.95, and root mean square error of approximation (RMSEA) ≤ 0.08.

Data Reduction and Descriptive Statistics for Children's Measures

Descriptive statistics for all parent and child measures are shown in Table 1. Children's performance improved significantly on each of the repeated measures of EF. Specifically children were more accurate on the Happy-Sad Stroop, M_{Diff} = 3.93, SD_{Diff} = 5.78, 95%CI [2.75, 5.10], t (102) = 6.63, $p < .001$, sorted more cards correctly in the post-switch phase of the DCCS, M_{Diff}= 1.62, SD_{Diff} = 2.58, 95%CI [1.12, 2.13], t (102) = 6.37, $p < .001$, and made fewer errors as a proportion of total trials on the SOPT, M_{Diff} = 0.05, SD_{Diff} = 0.06, 95%CI [0.03, 0.06], t (102) = 7.28, $p < .001$. Correlations between measures of EF were moderate at Time 1, $.29 < r < .48$, Mean $r = .40$, and weak to moderate at Time 2, $.08 < r < .73$, Mean $r = .33$. The SOPT error score at Time 2 was not correlated with any other measure of EF at Time 2 and so was not included in any further analyses. As reported elsewhere (Devine, Bignardi & Hughes, 2016), we tested a measurement model in which each EF indicator at Time 1 loaded onto one latent factor and each EF indicator at Time 2 loaded onto a separate latent factor. The error terms for the two DCCS indicators at Time 2 were permitted to correlate. This model provided an acceptable fit to the data, χ (12) – 16.47, p = 0.17, CFI = 0.97, TLI = 0.96, RMSEA = 0.06. All indicators loaded significantly (all ps < .01) onto the Time 1 EF latent factor, Standardized Estimates: .50 – .78, and all but one indicator (i.e., the DCCS Post-Shift score) loaded significantly onto the Time 2 EF latent factor, Standardized Estimates: .24 - .60. The factor determinacy co-efficient was 0.87 for the Time 1 latent factor and 0.84 for the Time 2 latent factor indicating high internal consistency (Brown, 2015). EF scores were therefore standardized and averaged to create a single EF variable for each time point.

There were strong concurrent and longitudinal correlations between each of the child measures (Table 2). Individual differences in EF and VA showed strong rank-order stability across time. EF at Time 1 remained significantly correlated with EF at Time 2 even when general cognitive ability and age (at Time 2) were controlled, *pr* (99) = .26, $p < .01$. VA at Time 1 remained correlated with VA at Time 2 even when age (at Time 2) and general cognitive ability were taken into account, *pr* (99) = .45, $p < .001$.

Data Reduction and Descriptive Statistics for Parents' Measures

Parents' performance on the measures of EF conformed to expectations. That is, parents were more efficient in their performance on the congruent trials, $M = 1.47$, $SD = 0.61$, 95%CI [1.35, 1.59], of the Arrows Task than on the incongruent trials, $M = 1.14$, $SD = 0.57$, 95%CI [1.02, 1.25], t (102) = 9.68, $p < .001$. Likewise there was a main effect of condition on performance on the Hearts and Flowers task, F (2, 204) = 592.38, $p < .001$. Efficiency scores were highest in the congruent condition, $M = 2.64$, $SD = 0.46$, 95%CI [2.55, 2.74], followed by the in the incongruent condition, $M = 2.03$, $SD = 0.56$, 95%CI [1.92, 2.14], and worst in the mixed condition, $M = 0.99$, $SD = 0.54$, 95%CI [0.89, 1.11], all contrasts were significant, *p*s < .01. Efficiency scores from both the Arrows Task (incongruent condition) and the Hearts and Flowers Task (mixed condition) were strongly correlated, r (101) = .60, $p < .001$, and so scores from each task were standardized and averaged together to create a single Parent EF variable ($\alpha = .75$).

Each of the PARCHISY items (i.e., Negative Control, Negative Affect and Conflict) were significantly inter-correlated, $.36 < r < .54$, all *p*s < .01. As reported elsewhere (Devine, Bignardi & Hughes, 2017) we tested a single latent factor measurement model in which each of these items loaded onto a 'Negative Parent-Child Interaction' factor. This latent factor exhibited significant variance, unstandardized estimate = 0.45, $p = .007$, and all item loadings were significant: Negative Control standardized estimate = .52, $p < .001$, Negative Affect standardized estimate = .68, $p < .001$, Conflict standardized estimate = .80, $p < .001$. The factor determinacy co-efficient was 0.87 indicating high internal consistency (Brown, 2015). PARCHISY items were therefore standardized and averaged to create a single 'Negative Parent-Child Interaction' score.

Main Analysis

Relations between parental behavior and children's EF and VA. We used structural equation modelling to investigate the uniqueness and specificity of the relations between each of the parental measures and individual differences in children's EF and VA at Time 2. We specified a longitudinal structural equation model with two correlated dependent variables: EF at Time 2 and VA at Time 2. Using an auto-regressive approach we regressed each dependent variable onto earlier scores on that variable at Time 1. We also regressed each of the dependent variables onto general cognitive ability at Time 1, SES and age at Time 2 to control for the effects of these variables. Finally we permitted each of the predictor variables to co-vary in the model.

This model provided an acceptable fit to the data, χ^2 (1) = 0.56, $p = .45$, CFI = 1.00, TLI = 1.07, RMSEA = 0. The model accounted for 48% of the variance in EF at Time 2 and 53% of the variance in VA at Time 2. To aid ease of interpretation only significant standardized parameter estimates for this longitudinal model are presented in Figure 1. The complete results for this model are presented in Table S1. Several findings from this model deserve note. There were general effects of the HLE on both EF at Time 2, $\beta = .14$, $p < .05$, 95%CI [.03, .25], and VA at Time 2, $\beta = .17$, $p < .05$, 95%CI [.04, .30]. Likewise there were general effects of parental MLU on later VA at Time 2, $\beta = .21$, $p < .01$, 95%CI [.07, .35], and on EF at Time 2, $\beta = -.14$, $p < .05$, 95%CI [-.25, -.03], but in opposite directions. Parent EF did not independently predict either child EF at Time 2, $\beta = .09$, $p = .19$, 95%CI [-.03, .22], or VA at Time 2, $\beta = .004$, $p = .95$, 95%CI [-.10, .10], once all other measures were taken into account. Negative parent-child interactions, $\beta = -.23$, $p < .01$, 95%CI [-.36, -.10], and parental scaffolding, $\beta = .19$, $p < .01$, 95%CI [.09, .29], showed unique specific associations with EF at Time 2 (each accounting uniquely for 4% of the variance in EF at Time 2) but not with VA at Time 2.

Uniqueness and specificity of the relations between parental behavior and children's EF and VA. To investigate whether the associations between parental negative parent-child interactions, parental scaffolding and EF at Time 2 were significantly different from the relations between these parental variables and VA at Time 2, we specified a model in which we constrained the regression paths between negative parent-child interaction and EF at Time 2 and negative parent-child interaction and VA at Time 2 to be equal. We also constrained the regression paths between parental scaffolding and EF at Time 2 and parental scaffolding and VA at Time 2 to be equal. These constraints resulted in a significant decrease in model fit, χ^2 (3) = 9.37, $p = .04$, CFI = 0.95, TLI = 0.66, RMSEA = 0.14, χ^2_{Diff} (2) = 8.81, $p < .05$, indicating that the strength of the paths linking the two parental behaviors and children's EF at Time 2 were significantly different than those linking the two parental behaviors and children's VA at Time 2. In summary, our model showed that negative parent-child interactions and parental scaffolding showed unique and specific associations with individual differences in children's EF but not with VA. In contrast the HLE and parental MLU were related to both EF and VA. Parental EF was unrelated to either children's EF or VA in the final model.

Supplementary analysis. To confirm our findings we tested our first auto-regressive longitudinal model using only those cases with complete data for all variables (N = 101). Once again this model provided an acceptable fit to the data, χ^2 (17) = 25.75, $p = .08$, CFI = 0.93, TLI = 0.92, RMSEA = 0.07. This model accounted for a similar proportion of the variance in Time 2 EF (47%) and Time 2 VA (53%) as the full information model. Crucially, each of the paths in this model showed the same pattern of findings as the full information model. Importantly, negative parent-child interactions were uniquely and specifically related to Time 2 EF, β = -.25, $p < .01$, 95%CI [-.43, -.07], but not Time 2 VA, β = -.10 $p = .25$, 95%CI [-.27, .07]. Furthermore, parental scaffolding showed unique and specific associations with Time 2 EF, β = .20, $p < .05$, 95%CI [.03, .36], but not Time 2 VA, β = .11, $p = .16$, 95%CI [-.04, .27].

Discussion

This study included multiple detailed measures of parental behavior as well as assessments of both parent EF and child EF across a 13-month period. Key questions concerned whether positive and negative parental behaviors: (i) show unique associations with child EF when considered in tandem; and (ii) show specific associations with child EF (rather than being related to children's cognitive ability in general). In relation to the first two questions our findings revealed that negative parent-child interactions (characterized by negative affect, criticism and control) showed a unique, specific *inverse* association with child EF while parental scaffolding showed a unique, specific *positive* association with child EF. In contrast, informal opportunities for learning (as measured by the Home Learning Environment questionnaire) and parental language input were related to both EF and verbal ability. Together, these findings support a differentiated model of parenting, in that each of the measures of parental behavior was largely distinct and showed different patterns of association with child EF and VA. Below, each set of findings is discussed in turn. In doing so, we also outline the strengths and limitations of our study and offer some suggestions for future research.

A Differentiated Model of Parental Influences on Children's EF

The growth of evidence that EF plays a central role in children's academic achievement (e.g., Blair & Razza, 2007) and behavioral adjustment (e.g., Hughes, White, Sharpen, & Dunn, 2000) has led to an explosion of research interest in family influences on children's EF. To date, with few exceptions (e.g., Bernier, et al., 2010; Hughes & Ensor, 2009), the great majority of studies on parental influences on children's EF have focused on single dimensions of parental behavior and have not examined the specificity of the effects of both positive and negative parental behaviors on children's EF.

Supporting a differentiated view of parental behavior (e.g., Carr & Pike, 2012; Hughes & Ensor, 2009; Zheng et al., 2016) our results showed that parental behaviors can be measured along distinct cognitive and affective dimensions. For instance the correlation matrix shows that negative parent-child interaction was inversely related to parental talk (MLU). That is, parents who engaged in extended discourse with their preschool child during the free play task were not necessarily more adept at fine-tuning the level of their support during the structured task or more likely to report providing their child with frequent learning opportunities (e.g., reading, painting etc.). This in itself is a point worth emphasising, in that it highlights the need for researchers to include a broad array of parenting measures in order to capture a full picture of social influences on children's cognitive development.

Our findings also have implications for educational and health professionals seeking to improve developmental outcomes for at-risk children. For example, Merz, Landry, Johnson, Williams and Jung (2016) have shown that an intervention designed to increase responsiveness in foster parents caring for children aged 2.5 to 5 years had limited benefits for children's EF, in that improvements in the intervention group were restricted to the youngest children in their sample. Coupled with findings from school-based interventions that highlight the need for an incremental approach to ensure that children continue to receive an appropriate level of challenge, our results indicate that family-based interventions to promote EF in preschool children should adopt a multi-pronged approach that goes beyond responsiveness to include a dual focus on promoting parents' cognitive scaffolding and reducing negative affect.

Parental Behaviors Show Both Overlapping and Specific Links With Children's EF and VA

Consistent with a domain-specific account of parental influences on children's EF, this study showed contrasting patterns of association between parental variables and children's ability. Specifically, parental scaffolding and negative parent-child interaction showed specific and unique associations with child EF (in the expected directions) and neither variable was associated with child VA. Confirming this, changes in model fit indicated that these paths showed a significant contrast in strength across the two cognitive domains (EF and VA). The specific link between negative parent-child interactions and children's EF is consistent with psychobiological accounts, which identify early negative experiences as stressors and highlight the vulnerability of EF to stress (Blair & Raver, 2015). Blair et al. (2011) have shown that the hypothalamic-pituitary-adrenal (HPA) axis functioning, as measured by elevated salivary cortisol mediates the link between stressful experiences and the emergence of EF. Future studies should investigate whether these mechanisms are specific to EF.

At first glance, the specificity of the association between parental scaffolding and child EF is surprising, as previous work has shown that language might play a mediating role in the association between parental scaffolding and later child EF (Landry et al., 2002). However, at least two between-study contrasts deserve note. The first of these is a clear difference in what is meant by parental scaffolding. In Landry et al.'s (2002) study (and in many other studies), the term 'scaffolding' encompasses a variety of supportive parental behaviors, including praise and encouragement. By contrast, in the current study we used the term 'scaffolding' much more tightly, to refer to the specific process of contingent shifting (e.g., Carr & Pike, 2012). By this definition, scaffolding can be and often is non-verbal. For example, parents might wordlessly remove all the non-edge pieces of a jigsaw to assist a child who is struggling to complete the perimeter of the puzzle. Similarly, scaffolding also includes reductions in the level of parental support in response to a child's display of mastery.

The second between-study contrast concerns the measurement of EF. While Landry et al. (2002) used children's goal-directed behavior within the parent-child structured play session to index child EF, the current study used four experimental tasks that did not require verbal responses. Thus in this study both the independent and dependent variables were less likely to entail verbal skills than the corresponding measures in the Landry et al. (2002) study. Note also that our finding of a specific link between parental scaffolding and child EF is consistent with the evidence from school-based interventions, which highlight the need for incremental challenges that enable practice to be tailored to a child's level of EF ability (Diamond & Lee, 2011**).** Thus the specificity of the relations between parental scaffolding and child EF also sheds light on the potential mechanisms that might underpin the socialization of EF in early childhood.

While the home learning environment showed a general association with child EF and VA, parental talk (as measured by the MLU) was associated in different directions with child VA and child EF. The negative association between parental MLU and child EF is puzzling but may reflect a child-driven effect: if children lack the EF skills to display autonomy, parents may find it necessary to provide more detailed conversational support during free play. Alternatively, a negative association between parental language input and children's EF could indicate that parents who talk too much might not be giving their children room to self-regulate. Further work is needed to distinguish between these alternative accounts.

One strength of the current study was its inclusion of both direct observational coding of parenting and self-report ratings of the home learning environment. This multi-measure approach enabled us to assess whether parental responses to child behaviors predict variation in gains in EF across a 13-month period, even when measures of the general home context (parental education, home learning environment, MLU) are taken into account. Our findings confirm the uniqueness of this association and also indicate the value of adopting a dual focus on both positive and negative as well as cognitive and affective dimensions of parental influence. The contrasting patterns of association between children's EF and VA with specific parental measures highlight the value of tailored interventions that focus on particular aspects of parenting to promote distinct aspects of cognitive development.

Parental EF, Parent-Child Interactions and Children's EF

In this study, negative parent-child interactions were related to low parental EF. This is an important finding, as negative parent-child interactions are associated with a range of long-term adverse outcomes including conduct problems (e.g.,Mills-Koonce, Willoughby, Garrett-Peters, Wagner, & Vernon-Feagans, 2016), anxiety (e.g., Wood, McLeod, Sigman, Hwang, & Chu, 2003) and depression (Cole et al., 2015). Understanding how EF skills can constrain parental responses to difficult situations may prove useful in reducing parental criticism or intrusiveness, particularly if parents attribute their responses to child characteristics rather than to their own cognitive profiles.

At the same time, this result needs to be interpreted with caution as the association between poor parental EF and negative parent-child interaction may simply reflect the common influence of a third variable. One plausible candidate in this respect is depression, which is associated with both reduced EF (e.g.,Austin, Mitchell, & Goodwin, 2001) and negative parenting (Lovejoy, Graczyk, O'Hare, & Neuman, 2000). The lack of any measure of parental wellbeing is a limitation of the current study and an obvious step for future research is to examine the independence and interplay of parental depression and EF as predictors of parental behaviors.

As noted in our introduction, genetic factors might also contribute to the association between parental EF and negative parent-child interaction and so the lack of a genetically sensitive design is a further limitation of the current study. That said, it is worth noting that genetic variation is typically most salient for phenotypic individual differences that are *general and stable*. In contrast, environmental factors typically show specific associations with changes in a specific ability or trait (Kovas, Haworth, Dale, & Plomin, 2007). By including a measure of child verbal ability in order to examine the *specificity* of associations between parental measures and by assessing *gains* in child EF across two time-points, this study minimized the extent to which the results might simply reflect genetic factors. Instead, our findings support psycho-biological models of regulation (e.g., Blair & Raver, 2015) in which stressful environments adversely affect the development of the prefrontal cortex, the neural substrate for EF. Future research might therefore profit from the inclusion of measures of children's stress levels during observed parent-child interactions (e.g., Blair et al., 2011).

Highlighting the specificity of the association between parental EF and negative parent-child interactions, our results showed that variation in parental EF was unrelated to individual differences in contingent shifting. At first glance, this null result is surprising: after all, contingent shifting is, by definition, a flexible response to changing situations and so should provide an ecological example of EF in action. One explanation may be that there is a 'transmission gap' between competence and performance (Meins, Fernyhough, Johnson, & Lidstone, 2006). That is, a parent with good EF might not utilize these skills when interacting with his or her child, perhaps because they lack experience in supporting children's goal-directed activities. Exploring whether parental expertise moderates the association between parental EF and contingent shifting would be an interesting avenue for future research. Note that the parental EF measures adopted in the current study focused on inhibition and task switching. Contingent shifting might therefore be related to other dimensions of EF not measured in the present study (e.g., working memory, the ability to monitor and update one's actions in response to changing circumstances). Future work would therefore benefit from incorporating a wider range of parental EF measures.

Finally our correlation table showed that, consistent with the general nature of genetic effects (Asbury & Plomin, 2014), parental EF showed associations with both children's EF and VA that were similar in magnitude. Moreover, our models indicated that-parental EF did not account for gains in children's EF above other factors such as the quality of parent-child interactions. Conceptually these findings suggest that intergenerational associations in cognitive ability are non-specific in nature and reflect a complex set of intervening variables rather than a deterministic association. For example, an impulsive parent is likely to adopt short-term strategies for managing children's behavior, which in turn might constrain children's developing skills in goal-directed tasks.

Study Limitations

Although this study extends previous findings on the relations between parental behavior and children's EF, a number of limitations deserve note. Given the time-consuming nature of observational coding our longitudinal study involved assessment of parental behavior at just one time point. That is, parent-child interactions were studied at Time 1 only and parental reports of the HLE and parental EF were assessed at Time 2 only. As a result, our model did not include developmental associations from child characteristics to later parenting behavior. While the impact of child behavior on parenting was included in our rating of scaffolding, a recent cross-lagged longitudinal study suggests that there may be bidirectional associations between EF and parental behavior (Blair, et al., 2014). While this finding underscores the importance of including parental measures at more than one time point (Zheng et al., 2016), it is worth stressing that our analyses controlled for stability in children's EF such that any observed relations indicate potential developmental influence on

EF (Menard, 2002) and despite their concurrent measurement, our findings highlight the relative independence of parental and child EF scores. The timing and format of measurement of parental behaviors might also account for the weak and non-significant correlations between different aspects of parental behavior. That said, EF in adulthood shows high levels of rank-order stability over time (e.g., Friedman et al., 2016) as do measures of the HLE across early childhood (e.g., Lehrl, Kluczniok, & Rossbach, 2016). Moreover we identified correlations between negative parent-child interactions (at Time 1) and parental EF (at Time 2). Future studies that incorporate parental measures at more than one time point will aid our understanding of the relations between parental behavior and parental EF.

Conclusions

The results of this study indicate that including multiple direct observational measures of parenting is labor well-spent, in that our findings confirm a multi-faceted model of parenting (Zheng, et al., 2016). First, separate measures of parental behavior (i.e., positive/negative and cognitive/affective) show distinct patterns of association with children's EF. Second, our findings confirm the domain-specificity of parental influences. That is, while scaffolding and negative parent-child interactions are both key predictors of child EF, highlighting the diversity of parental influences on child EF, they were unrelated to children's VA. In contrast, the home learning environment was positively related to both child outcomes and parental MLU was positively related to child VA but negatively related to child EF. While unexpected, this last finding highlights the importance of going beyond simple quantitative measures of talk to focus on the quality of parent-child interactions in supporting children's cognitive development (Hirsh-Pasek et al., 2015). By adopting multi-dimensional measures of parental behavior in studies that include more diverse samples and genetically sensitive designs, we hope that future research will expand our understanding of positive and negative parental influences on children's EF.

References

Asbury, K. & Plomin, R. (2014). *G is for Genes: The Impact of Genetics on Education and Achievement*. Oxford, UK: Wiley Blackwell.

Austin, M., Mitchell, P., & Goodwin, G. (2001). Cognitive deficits in depression: Possible implications for functional neuropathology. *British Journal of Psychiatry, 178*, 200-206. DOI: 10.1192/bjp.178.3.200

Bernier, A., Carlson, S., & Whipple, N. (2010). From external regulation to self-regulation: Early parenting precursors of young children's executive functioning. *Child Development, 81*, 326-339. DOI: 10.1111/j.1467-8624.2009.01397.x

Blair, C., Granger, D., Willoughby, M., Mills-Koonce, R., Cox, M., Greenberg, M., Kivlighan, K.T., Fortunato, C., & The FLP Investigators (2011). Salivary Cortisol Mediates Effects of Poverty and Parenting on Executive Functions in Early Childhood. *Child Development, 82* 1970-1984. DOI: 10.1111/j.1467-8624.2011.01643.x

Blair, C., & Raver, C. (2015). School readiness and self-regulation: a developmental psychobiological approach. *Annual Review of Psychology, 66*, 711-731. DOI: 10.1146/annurev-psych-010814-015221

Blair, C., Raver, C., & Berry, D. (2014). Two approaches to estimating the effect of parenting on the development of executive function in early childhood. *Developmental Psychology, 50*, 554-565. DOI:10.1037/a0033647

Brown, T. (2015). *Confirmatory Factor Analysis for Applied Research* (Second ed.). London: Guilford Press.

Carr, A., & Pike, A. (2012). Maternal scaffolding behavior: Links with parenting style and maternal education. *Developmental Psychology, 48*, 543-551. DOI:10.1037/a0025888

Cole, D., Sinclair-McBride, K., Zelkowitz, R., Bilsk, S., Roeder, K., & Spinelli, T. (2015). Peer Victimization and Harsh Parenting Predict Cognitive Diatheses for Depression in

Children and Adolescents. *Journal of Clinical Child and Adolescent Psychology, 13*, 1537-4416 DOI: 10.1080/15374416.2015.1004679

Cragg, L., & Nation, K. (2007). Self-ordered pointing as a test of working memory in typically developing children. *Memory, 15*, 526 - 535. DOI: 10.1080/09658210701390750

Cuevas, K., Deater-Deckard, K., Kim-Spoon, J., Wang, Z., Morasch, K., & Bell, M. (2014). A longitudinal intergenerational analysis of executive functions during early childhood. *British Journal of Developmental Psychology, 32*, 50-64. DOI:10.1111/bjdp.12021

Cuevas, K., Deater-Deckard, K., Kim-Spoon, J., Watson, A., Morasch, K., & Bell, M. (2014). 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, 17*, 224-238. DOI: 10.1111/desc.12073

Davidov, M. (2013). The socialization of self-regulation from a domains perspective. In G. Seebaß, M. Schmitz. & P.M. Gollwitzer (Eds). Acting Intentionally and its Limits: Individuals, Groups, Institutions (pp. 223-244). Berlin, Germany: De Gruter.

Davidson, M., Amso, D., Anderson, L., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia,, 44*, 2037-2078. DOI: 10.1016/j.neuropsychologia.2006.02.006

Deater-Deckard, K., Pylas, M., & Petrill, S. (1997). *Parent-Child Interactive System (PARCHISY).* London: Institute of Psychiatry, King's College London.

Devine, R.T., Bignardi, G., & Hughes, C. (2016). Executive Function Mediates the Relations between Parental Behaviors and Children's Early Academic Ability. *Frontiers in Psychology. 7*,1902. doi: 10.3389/fpsyg.2016.01902

Devine, R.T. & Hughes, C. (2014). Relations between false belief understanding and executive function in early childhood: a meta-analysis. *Child Development, 85*, 1777-1794. DOI: 10.1111/cdev.12237

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. *Science*, *333*, 959-964. DOI: 10.1126/science.1204529

Eley, T.C. & Stevenson, J. (1999). Exploring covariation between anxiety and depression symptoms: A genetic analysis of the effects of age and sex. *Journal of Child Psychology and Psychiatry, 40*, 1273 - 1282. DOI: 10.1111/1469-7610.00543

Fay-Stammbach, T., Hawes, D.J. & Meredith, P. (2014). Parenting influences on executive function in early childhood: A review. *Child Development Perspectives, 8*, 258-264. DOI: 10.1111/cdep.12095

Friedman, N., Miyake, A., Altamirano, L., Corley, R., Young, S., Rhea, S., & Hewitt, J. (2016). Stability and change in executive function abilities from late adolescence to early adulthood: A longitudinal twin study. *Developmental Psychology, 52*, 326-340. DOI: 10.1037/dev0000075.

Garon, N., Bryson, S., & Smith, I. (2008). Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin, 134*, 31-60. DOI: 10.1037/0033-2909.134.1.31.

Gerstadt, C., Hong, Y., & Diamond, A. (1994). The relationship between cognition and action: performance of children 31/2 - 7 years old on a stroop-like day-night test. *Cognition, 53*, 129-153. DOI: 10.1016/0010-0277(94)90068-X

Hammond, S., Muller, U., Carpendale, J., Bibok, M., & Lieberman-Finestone, D. (2012). The effects of parental scaffolding on preschoolers' executive function. *Developmental Psychology*, *48*, 271-281. DOI: 10.1037/a0025519

Hertzog, C., & Nesselroade, J. (2003). Assessing psychological change in adulthood. *Psychology and Aging, 18,* 639-657. DOI: 10.1037/0882-7974.18.4.639

Hirsh-Pasek, K., Adamson, L., Bakeman, R., Owen, M., Golinkoff, R., Pace, A., Yust, P.K., & Suma, K. (2015). The Contribution of Early Communication Quality to Low-Income Children's Language Success. *Psychological Science*, *26*, 1071-1083. DOI: 10.1177/0956797615581493

Hoff, E. (2006). How social contexts support and shape language development. *Developmental Review,, 26* 55-88. DOI: 10.1016/j.dr.2005.11.002

Hughes, C., & Ensor, R. (2005). Theory of Mind and Executive Function in 2-year-olds: A family affair? *Developmental Neuropsychology, 28*, 645-668. DOI: 10.1207/s15326942dn2802_5

Hughes, C., & Ensor, R. (2007). Positive and Protective: Effects of Early Theory of Mind on Preschool Problem Behaviors. *Journal of Child Psychology and Psychiatry, 48*, 1025-1032. DOI: 10.1111/j.1469-7610.2007.01806.x

Hughes, C., & Ensor, R. (2009). How do families help or hinder the development of executive function? *New Directions in Child and Adolescent Psychiatry: Special Issue on social interaction and the development of executive function, 123*, 35-50. DOI:10.1002/cd.234.

Hughes, C., Graham, A., & Grayson, A. (2005). Executive Function in Childhood: Development and disorder. In J. Oates (Ed.), *Cognitive Development* (pp. 205-230): Open University Press.

Hughes, C., Roman, G., Hart, M., & Ensor, R. (2013). Does Maternal Depression Predict Young Children's Executive Function? A 4-year Longitudinal Study. *Journal of Child Psychology and Psychiatry, 54*, 169-177. DOI: 10.1111/jcpp.12014

Hughes, C., White, A., Sharpen, J., & Dunn, J. (2000). Antisocial, angry and unsympathetic: 'Hard to manage' preschoolers' peer problems, and possible social and cognitive influences. *Journal of Child Psychology and Psychiatry, 41*, 169-179. DOI: 10.1111/1469-7610.00558

Kolb, B., Mychasiuk, R., Muhammad, A., Li, Y., Frost, D., & Gibb, R. (2012). Experience and the developing prefrontal cortex. *Proceedings of the National Academy of Sciences of the United States of America*, *109* 17186-17193. DOI: 10.1073/pnas.1121251109

Kovas, Y., Haworth, C., Dale, P., & Plomin, R. (2007). *The Genetic and Environmental Origins of Learning Abilities and Disabilities in the Early School Years* (Vol. 72). Boston: Blackwell.

Lagattuta, K., Sayfan, L., & Monsour, M. (2011). A new measure for assessing executive function across a wide age range: Children and adults find happy-sad more difficult than day-night. *Developmental Science*, *14*, 481-489. DOI:10.1111/j.1467-7687.2010.00994.x

Landry, S.H., Miller-Loncar, C.L., Smith, K.E., Swank, P.R. (2002). The role of early parenting in children's development of executive processes. *Developmental Neuropsychology*, *21*, 15-41. DOI: 10.1207/S15326942DN2101_2

Lehrl, S., Kluczniok, K., & Rossbach, H. (2016). Long-term associations of preschool education: the predictive role of preschool quality for the development of mathematical skills through elementary school. *Early Child Research Quarterly, 36*, 475-488. DOI: 10.1016/j.ecresq.2016.01.013

Leve, L., DeGarmo, D., Bridgett, D., Neiderhiser, J., Shaw, D., Harold, G., Natsuaki, M.N., & Reiss, D. (2013). Using an adoption design to separate genetic, prenatal, and temperament influences on toddler executive function. *Developmental Psychology, 49*, 1045-1057. DOI:10.1037/a0029390

Lovejoy, M., Graczyk, P., O'Hare, E., & Neuman, G. (2000). Maternal depression and parenting behavior: A meta-analytic review. *Clinical Psychology Review, 20*, 561-592. DOI: 10.1016/S0272-7358(98)00100-7

Mackenzie, M., Nicklas, E., Waldfogel, J., & Brooks-Gunn, J. (2012). Corporal Punishment and Child Behavioral and Cognitive Outcomes through 5Years of Age: Evidence from a Contemporary Urban Birth Cohort Study. *Infant and Child Development,, 21*, 3-33. DOI: 10.1002/icd.758

Meins, E. (1997). Security of attachment and maternal tutoring strategies: Interaction within the zone of proximal development. *British Journal of Developmental Psychology, 15,* 129-144. DOI: 10.1111/j.2044-835X.1997.tb00730.x

Meins, E., Fernyhough, C., Johnson, F., & Lidstone, J. (2006). Mind-mindedness in children: Individual differences in internal-state talk in middle a childhood. *British Journal of Developmental Psychology, 24*, 181-196. DOI: 10.1348/026151005X80174

Melhuish, E., Sylva, K., Sammons, P., Siraj-Blatchford, I., Taggart, B., Phan, M., & Malin, A. (2008). Preschool influences on mathematics achievement. *Science, 321*, 1161-1162. DOI:10.1126/science.1158808

Menard, S. (2002). *Longitudinal Research* (Second ed.). London: Sage.

Merz, E., Harlé, K., Noble, K., & Mccall, R. (2016). Executive Function in Previously Institutionalized Children. *Child Development Perspectives*, 10, 105-110. DOI: 10.1111/cdep.12170

Merz, E., Landry, S., Johnson, U., Williams, J., & Jung, K. (2016). Effects of a responsiveness-focused intervention in family child care homes on children's executive function. *Early Childhood Research Quarterly, 34,* 128-139. DOI: 10.1016/j.ecresq.2015.10.003

Mills-Koonce, W., Willoughby, M., Garrett-Peters, P., Wagner, N., & Vernon-Feagans, L. (2016). The interplay among socioeconomic status, household chaos, and parenting in the prediction of child conduct problems and callous-unemotional behaviors. *Development and Psychopathology, 28,* 757-771. DOI: 10.1017/S095457941600029

Miyake, A., Friedman, N., Emerson, M., Witzki, A., Howerter, A., & Wager, T. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*, 49-100. DOI: 10.1006/cogp.1999.0734

Mulvaney, M., McCartney, K., Bub, K., & Marshall, N. (2006). Determinants of dyadic scaffolding and cognitive outcomes in first graders. *Parenting: Science and Practice, 6,* 297–320. DOI:10.1207/s15327922par0604_2

Noble, K., Norman, M. F., & Farah, M. (2005). Neurocognitive correlates of socioeconomic status in kindergarten children. *Developmental Science, 8*, 74-87. DOI: 10.1111/j.1467-7687.2005.00394.x

Pratt, M., Green, D., MacVicar, J., & Bountrogianni, M. (1992). The mathematical parent: Parental scaffolding, parenting style, and learning outcomes in long-division mathematics homework. *Journal of Applied Developmental Psychology, 13*, 17-34. DOI: 10.1016/0193-3973(92)90003-Z

Rust, J. (2003). *The Wechsler Preschool and Primary Scale of Intelligence (WPPSI III UK)* (Third ed.). London: Harcourt Assessments.

Smetana, J.G. (2017). Current research on parenting styles, dimensions and beliefs. *Current Opinon in Psychology, 15*, 19 - 25. DOI: 10.1016/j.copsyc.2017.02.012

Son, S., & Morrison, F. (2010). The nature and impact of changes in home learning environment on development of language and academic skills in preschool children. *Developmental Psychology, 46*, 1103-1118. DOI: 10.1037/a0020065

Tausczik, Y., & Pennebaker, J. (2010). The psychological meaning of words: LIWC and computerized text analysis methods. *Journal of Language and Social Psychology, 29*, 24-54. DOI: 10.1177/0261927X09351676

Ursache, A., & Noble, K. (2016). Neurocognitive development in socioeconomic context: Multiple mechanisms and implications for measuring socioeconomic status. *Psychophysiology, 53*, 71-82. DOI: 10.1111/psyp.12547

Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes*. Cambridge MA: Harvard University Press.

Wiebe, S.A., Espy, K.A. & Charak, D. (2008). Using confirmatory factor analysis to understand executive control in preschool children: I. Latent structure. *Developmental Psychology*, *44*, 575 - 87. DOI: 10.1037/0012-1649.44.2.575

Wood, D., Bruner, J., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry, 17*, 89-100. DOI:10.1111/j.1469-7610.1976.tb00381.x

Wood, D., & Middleton, D. (1975). A study of assisted problem-solving. *British Journal of Psychology*, *66*, 181-191. DOI: 10.1111/j.2044-8295.1975.tb01454.x

Wood, J., McLeod, B., Sigman, M., Hwang, W., & Chu, B. (2003). Parenting and childhood anxiety: Theory, empirical findings, and future directions. *Journal of Child Psychology and Psychiatry, 44*, 134-151. DOI: 10.1111/1469-7610.00106

Zelazo, P. (2006). The Dimensional Change Card Sort (DCCS): a method of assessing executive function in children. *Nature Protocols*, *1*, 297 - 301. DOI: 10.1038/nprot.2006.46

Zheng, Y., Pasalich, D., Oberth, C., McMahon, R., & Pinderhughes, E. (2016). Capturing Parenting as a Multidimensional and Dynamic Construct with a Person-Oriented Approach. *Prevention Science*, 1-11. DOI: 10.1007/s11121-016-0665-0

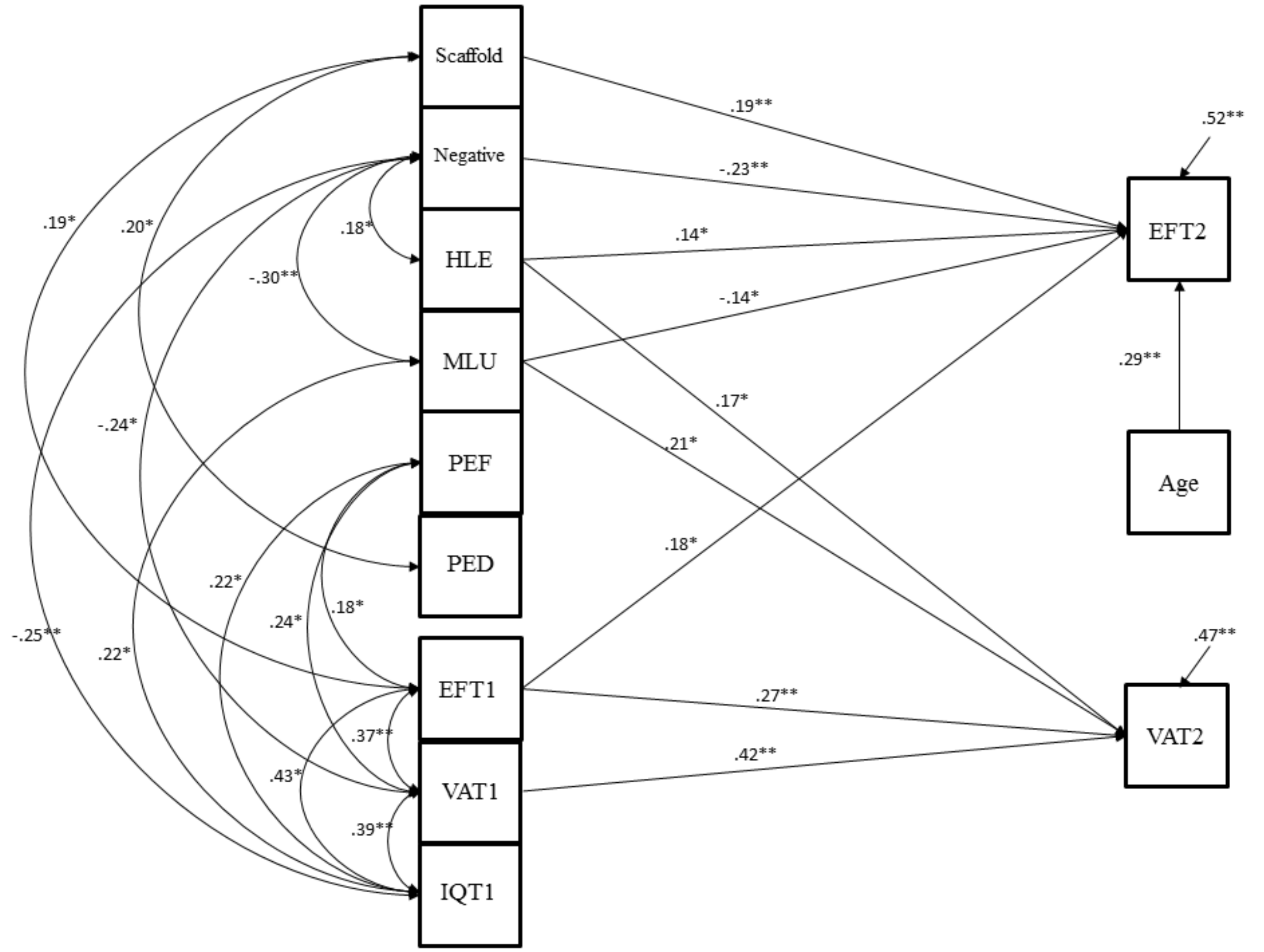

Figure 1. Standardized Robust Maximum Likelihood Estimates for Longitudinal Model.
Note. **p < .01. *p < .05. Only significant paths are depicted. Full model results are shown in Table S1. EF = Executive Function. VA = Verbal Ability. IQ = General Cognitive Ability. Scaffold = Parental Scaffolding. Negative = Negative Parent-Child Interactions. HLE = Home Learning Environment. MLU = Parent Mean Length of Utterance. PEF = Parent Executive Function. PED = Parent Education. T1 = Time 1. T2 = Time 2.

Table 1. *Descriptive Statistics*

	Time 1			Time 2		
	M (SD)	**95% CI**	**Range**	**M (SD)**	**95% CI**	**Range**
Child Measures						
Happy-Sad Stroop	13.35 (6.30)	12.17, 14.53	0 – 20	17.24 (2.42)	16.77, 17.71	7 – 20
DCCS Post-Switch	3.74 (2.50)	3.29, 4.19	0 – 6	5.36 (1.63)	5.04, 5.67	0 – 6
Self-Ordered Pointing Task	0.13 (0.06)	0.12, 0.14	0 - 0.28	0.08 (0.04)	0.07, 0.09	0 – 0.22
DCCS Border Game	-	-	-	6.57 (2.86)	6.02, 7.12	0 – 12
Day-Night Stroop	-	-	-	17.26 (1.98)	16.87, 17.65	12 – 20
Receptive Vocabulary	23.04 (5.12)	22.12, 23.96	8 – 31	27.08 (3.82)	26.34, 27.82	17 – 34
Object Assembly	16.71 (8.24)	15.22, 18.20	2 – 35	-	-	-
Parent Measures						
Parental Control	49.94 (7.89)	48.44, 51.44	41.26 – 82.49	-	-	-
Parental Scaffolding	0.42 (0.20)	0.38, 0.46	0 – 1	-	-	-
Mean Length of Utterance	5.25 (0.99)	5.05, 5.45	3.37 – 9.10	-	-	-
Home Learning Environment	-	-	-	30.44 (9.78)	28.56, 32.32	8 – 49
Arrows Efficiency (trial/s)	-	-	-	1.14 (0.57)	1.03, 1.25	0 – 2.15
Hearts/Flowers Efficiency (trial/s)	-	-	-	0.99 (0.54)	0.88, 1.09	0 – 2.39

Table 2. *Sample Correlations.*

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Child Executive Function T1	-											
2. Child Executive Function T2	.49**	-										
3. Child Verbal Ability T1	.37**	.42**	-									
4. Child Verbal Ability T2	.47**	.48**	.59**	-								
5. Child Cognitive Ability T1	.43**	.42**	.39**	.37**	-							
6. Child Age (Concurrent)	.55**	.51**	.51**	.46**	.52**	-						
7. Child Gender	-.09	-.15	-.16	-.09	.09	.05	-					
8. Negative Parent-Child Interaction	-.09	-.29**	-.21*	-.25*	-.25**	-.07	.19*	-				
9. Parental Scaffolding	$.18^{+}$	.26**	.10	.20*	.02	.02	-.06	-.12	-			
10. HLE	.03	.10	.04	$.18^{+}$	-.05	-.01	-.22*	.18*	.05	-		
11. MLU	.10	.001	.06	.32**	.20*	.07	.02	-.30**	.01	.06	-	
12. Parent Executive Function	$.18^{+}$	.22*	.24*	.16	.23*	.02	-.06	-.22*	-.06	-.06	-.03	-
13. Parent Education	.16	.15	.15	.12	.12	-.04	.06	.05	.20*	.08	.12	.07

Note. ***p* < .01. **p* < .05. $^{+}p < .10$. T1 = Time 1. T2 = Time 2. 103 < *N* < 117. T1 = Time 1. T2 = Time 2. HLE = Home Learning Environment. MLU = Mean Length of Utterance.