HOUSEHOLD CHAOS, MATERNAL DISTRESS AND PARENTING: ASSOCIATIONS WITH CHILD FUNCTION ACROSS MULTIPLE DOMAINS

HOUSEHOLD CHAOS, MATERNAL DISTRESS AND PARENTING: ASSOCIATIONS WITH CHILD FUNCTION ACROSS MULTIPLE DOMAINS

By

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Lay Abstract

Children exposed to household chaos may experience adverse outcomes across multiple domains. Parenting can also be negatively affected by household chaos which may impact the quality of parent-child interactions. Further, the physical and psychological health of the mother may regulate the levels of chaos in the home which has implications for child outcomes as well. This dissertation seeks to examine the influence of household chaos on child executive functioning, stress levels and socioemotional functioning, and the roles that parenting and maternal distress play. I address three primary objectives: 1) using meta-analytic techniques, I examine the magnitude of effect of household chaos on child executive functioning based on existing literature as well as potential factors that may modulate the strength of the linkage between household chaos and child executive functioning; and using cross-sectional data, I examine 2) how household chaos impacts parenting and subsequently, how parenting impacts child executive functioning; and 3) how maternal distress influences the level of chaos in the home and how this chaos impacts child stress levels and socioemotional functioning. Collectively, the results from this dissertation indicate that household chaos has a broad negative impact on child outcomes, and both parenting and maternal distress play important roles in understanding this impact. Further, it demonstrates the need for intervention research aimed at supporting the physical and psychological health of mothers, improving parenting and creating order and stability in homes for children.

Abstract

Proximal risk factors including household chaos, parenting and maternal distress can have a broad impact on multiple domains of child development and functioning. Using multiple methodologies including a meta-analysis and structural equation modeling with an empirical, cross-sectional design from a larger longitudinal research study; in this dissertation, I examine the impact of household chaos on child executive functioning, socioemotional and physiological stress outcomes, the role that parenting plays in this association, and how maternal distress predicts chaos in the home. In study 1, I conduct a meta-analysis examining the direct association between household chaos and child executive functioning, as well as multiple potential moderators (e.g. child age, sex and race/ethnicity). It incorporates 26 studies, with 27 independent effect sizes with a total sample of 8,944 children. Overall, I found a significant effect of r = .22 between household chaos and child executive function. Among the moderators assessed, only measurement approach of executive functions (informant-completed questionnaire versus direct assessment) was significant, with informant-completed questionnaires yielding an effect of r = .27 compared to direct assessment, r = .16. I conducted a series of separate moderation analyses for questionnaire and direct assessment effects. No significant moderators emerged from the questionnaire analyses, despite heterogeneous effect sizes. Direct assessment analyses revealed that both household chaos dimensions (disorganization and instability) were significantly related to child executive functions, however instability was a stronger correlate (r = .21) than disorganization (r = .09). Composition of the sample was also a significant moderator with effects increased with the proportion of minorities, and with parents with lower levels of education. Building on this work, in studies 2 and 3, I used cross-sectional empirical data from a sample of 137 mothers and their school-aged (5-year old) children. During home visits, mothers

completed questionnaires assessing their mood, stressful experiences, the home environment and their child's socioemotional functioning. Mothers also completed a video tour of the home. Mother-child interactions were videotaped and later coded for parenting. Both mothers and children independently completed behavioural assessments of executive function. Also, hair samples were collected from mothers and children from which the stress hormone, cortisol, was extracted as a biomarker of chronic stress. In order to empirically test the findings from the meta-analysis, in my second study, I used structural equation modeling to examine the indirect effect of household chaos on child executive functioning via parenting. I found that household chaos was directly and indirectly (via maternal cognitive sensitivity and emotional availability) associated with a latent variable of child executive functioning. Furthermore, instability, but not disorganization, significantly predicted child executive functioning directly and indirectly via parenting. Finally, sex-based analyses indicated that the effect of chaos on child executive functioning was significant through indirect effects only for boys. In the third study, in order to elucidate potential contributing factors to household chaos, I used a structural equation model to examine the indirect effects of a linear regression-weighted composite variable of maternal distress (depression, negative affect and physiological stress) on child hair cortisol levels and externalizing and internalizing behaviour problems via household chaos. I found that maternal distress had both direct and indirect effects (via household chaos) on child hair cortisol levels; however, only indirect effects were significant for externalizing and internalizing behaviour problems. Also, the indirect effect was only significant for household disorganization, but not instability, for child hair cortisol and externalizing and internalizing behaviour problems. Taken together, the findings from my dissertation demonstrate that: 1) household chaos has a direct, negative effect on child executive functioning and an indirect effect via parenting; and 2)

maternal distress plays an important role in predicting the levels of chaos within the home which has implications for child chronic stress levels and behavioural problems. Collectively, these findings highlight the need to take a multi-method approach to measuring executive functioning in children and further, to develop and evaluate interventions that aim to support mothers, improve parenting and promote order and stability within the home in order to foster healthy developmental trajectories for children.

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First and foremost, I would like to express my genuine gratitude to my supervisor, Dr. Andrea Gonzalez for her limitless support and mentorship throughout this PhD. Her intellect, dedication, creativity and passion for research has been illuminating. Her genuine desire to understand the ways to minimize the challenges faced by vulnerable populations has sparked my interest in continuing research in this field. Her work ethic, humility and kindness has been an example that I aim to continue to work towards in my personal and professional life and it has been an honour to work with her.

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I am also grateful to our research team (the old and the new) and the many wonderful members of the Offord Centre for providing a nurturing and yet, challenging environment that has contributed to my growth as a scientist. Thank you also to the families who gave their time to participate in our studies as this work is not possible without you.

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Declaration of Academic Achievement

This dissertation encompasses three studies that were conceptualized and written by the student. Two of the three studies include the use of empirical, cross-sectional data from a larger longitudinal design developed by the student's thesis supervisor, Dr. Andrea Gonzalez. The work for this dissertation was completed between September 2015 and November 2019. Specific to the components of this dissertation, the student was involved in the development of study design and protocol, ethics approval and data collection. Analyses for the three studies were also completed by the student as well as manuscripts prepared for publication. The contributions of co-authors in each study are described below as per the requirements of the sandwich thesis.

In Study 1, a meta-analysis was conducted to examine the direct effect of household chaos on child executive functioning. Its co-authors were Dr. Andrea Gonzalez, Dr. Leslie Atkinson of Ryerson University and Madeleine Harris, a graduate student and member of Dr. Gonzalez's research team. Dr. Andrea Gonzalez provided insight on the theoretical rationale, and critically reviewed the manuscript prior to submission for publication. Dr. Leslie Atkinson provided ongoing expertise regarding the methodology involved in the meta-analysis and critically reviewed the manuscript prior to submission. Madeleine Harris acted as the second independent coder involved in study selection and coding of moderators and also critically reviewed the manuscript prior to submission.

In Study 2, empirical, cross-sectional data was used to examine the direct and indirect effects (via parenting) of household chaos on child executive functioning. Its co-authors were Dr. Andrea Gonzalez, Dr. Leslie Atkinson, Dr. James Dunn of the Department of Health, Aging, & Society at McMaster University, and Drs. Heather Prime and Eric Duku, members of Offord Centre for Child Studies at McMaster University. Dr. Andrea Gonzalez is the principal

investigator of the larger longitudinal study from which part of the final sample was derived for the current study. Dr. Gonzalez was involved in regular consultation and critically reviewed the manuscript. Dr. Leslie Atkinson critically reviewed the manuscript. Dr. James Dunn provided consultation regarding theoretical rationale and methodology for the study, and critically reviewed the manuscript. Dr. Heather Prime developed the cognitive sensitivity instrument used in the parenting analyses and provided a critical review of the manuscript. Dr. Eric Duku provided statistical expertise regarding structural equation modeling and critically reviewed the manuscript.

In Study 3, empirical, cross-sectional data was used to examine the direct and indirect effects (via household chaos) of maternal distress on child hair cortisol levels and socioemotional functioning. Its co-authors were Dr. Andrea Gonzalez, Dr. Leslie Atkinson, Dr. James Dunn, and Dr. Eric Duku. Dr. Andrea Gonzalez is the principal investigator of the larger longitudinal study from which part of the final sample was derived for the current study. Dr. Gonzalez was involved in regular consultation and critically reviewed the manuscript. Dr. Leslie Atkinson critically reviewed the manuscript. Dr. James Dunn provided consultation regarding theoretical rationale and methodology for the study, and critically reviewed the manuscript. Dr. Eric Duku provided statistical expertise regarding structural equation modeling and critically reviewed the manuscript.

Chapter 1: General Introduction

Statement of Purpose

The purpose of this dissertation is threefold: 1) to examine the impact of household chaos on multiple domains of child functioning; 2) to explore the role of parenting in these associations; and 3) to explore the role of maternal distress as a factor influencing levels of chaos in the home. In the first chapter, I introduce and discuss the main concepts across the studies, and the associations between them based on extant literature. In chapters 2 to 4, I describe three individual studies that examine associations between these main concepts via multiple methodologies including a meta-analysis and structural equation modeling with an empirical, cross-sectional design from a larger longitudinal research study. In the first study, described in chapter 2, I use meta-analytic techniques to identify the magnitude of effect of household chaos directly on child executive functioning based on the current state of the literature. Additionally, moderator analyses are conducted to explore potential factors that influence the strength of this association. In the second and third studies, described in chapters 3 and 4 respectively, I extend findings from the first study to propose direct and indirect effect models using empirical data, to better elucidate the underlying mechanisms involved in the impact of household chaos on child outcomes. Specifically, in the second study, I use structural equation modeling to examine the indirect effect of household chaos on a latent construct of child executive functioning via parenting – maternal cognitive sensitivity and emotional availability. Analyses in this study involved: examining possible differential

effects of each dimension of household chaos – disorganization and instability - and testing possible sex-based differences in the indirect effect model. In the third study, I propose that maternal distress – characterized by maternal depressive symptoms, negative affect and stress physiology – may influence levels of chaos in the home which in turn, impacts the socioemotional functioning and stress physiology of the child. This is explored via testing a structural equation model of the indirect effect of a linear regression-weighted composite of maternal distress on child hair cortisol levels and externalizing and internalizing behaviour problems via household chaos. The final fifth chapter summarizes the collective main findings of the previous three chapters in a general discussion, as well as presents the implications of these findings for future research and interventions.

1.1 Bronfenbrenner's Bioecological Theory of Human Development

1.1.a. Overview of Theoretical Framework

Bronfenbrenner's bioecological theory of human development has evolved across the decades (1973-2006). Broadly speaking, it emphasizes the reciprocal interactions between the child and their most proximal and distal environments. Four core nested systems comprise these interacting contexts, as well as a fifth temporal-based system (Bronfenbrenner, 1986a, 1986b). The microsystem refers to the direct interactions the child has with their immediate external environment (e.g. family, school, neighbourhood, daycare) (Bronfenbrenner & Morris, 1998). The mesosystem describes interactions between the child's immediate environments. For example, the exchange between the parent (family microsystem) and teacher (school microsystem) of a child in discussing the

child's behaviour in the classroom (Neal & Neal, 2013). The exosystem refers to the environments that the child may not directly interact with, but are still influenced by (e.g. parent's workplace, school board). The macrosystem describes the larger cultural context within which the child lives and its inherent values, customs, laws, politics and economics. The chronosystem focuses on changes or continuities across time that influence the environments and the child (e.g. child entering school) (Bronfenbrenner, 1986b, 1986a). Altogether, this network of environments influences child development both directly and indirectly. As such, understanding the different associations within the framework is important in grasping the ways in which these environments impact the child's overall functioning. The microsystem is particularly important to the early development of the child as these direct, proximal processes play a significant role during a sensitive period of development in shaping the physiological, cognitive and behavioural outcomes of the child (Rosa & Tudge, 2013).

1.1.b. A Focus on the Microsystem

The microsystem, and in particular, the family unit, is of particular importance in understanding early development (Rosa & Tudge, 2013). Proximal processes, considered the engines of development (Bronfenbrenner & Evans, 2000), are a core tenet of the bioecological theory (Rosa & Tudge, 2013); and refers to the: "…transfer of energy between the developing human being and the persons, objects, and symbols in the immediate environment" (Bronfenbrenner & Evans, 2000, p. 118). In other words, these are increasingly complex reciprocal interactions that the developing child has with elements of their immediate environment (Bronfenbrenner & Morris, 1998, 2006). These

processes may lead to outcomes reflecting a level of competence or dysfunction. Competence refers to the child acquiring and developing knowledge or a skill within any domain (e.g. cognitive, physical, socioemotional) and being able to use this acquired information to direct their behaviour across time and settings. Conversely, dysfunction describes frequent challenges in managing behaviours across developmental domains and settings (Bronfenbrenner & Morris, 1998). A child's exposure to particular proximal processes can be influenced by contextual factors via variations in frequency, duration, interruptions, intensity and timing of exposure (Bronfenbrenner & Evans, 2000). For example, according to Bronfenbrenner, it is likely that proximal processes within stable and advantageous environments will lead to outcomes of competence; whereas those environments characterized by instability and disadvantage will lead to proximal processes resulting in dysfunctional outcomes (Bronfenbrenner & Morris, 1998, 2006; Bronfenbrenner & Evans, 2000). In this dissertation, I consider the effect of one contextual factor in particular – household chaos (disorganization and instability within the home) - on proximal processes in the child's microsystem. Specifically, I examine whether high levels of chaos in the home threaten the integrity of otherwise constructive proximal processes and contribute to adverse processes that can impact child cognitive, physiological and socioemotional outcomes. This is a timely and important topic given that levels of household chaos are growing exponentially in North American homes (Bronfenbrenner, McClelland, Wethington, Moen, & Ceci, 1996; Lichter & Wethington, 2010).

1.2 Household Chaos

1.2.a. Household Chaos: Definition and Dimensions

Several definitions have been put forth in describing household chaos. Evans (2006) describes it as an aspect of the physical environment characterized by chronic noise and crowding (Evans, 2006). Earlier works defined it as: "environmental confusion" referring to high levels of noise, crowding and home traffic pattern (Matheny, Wachs, Ludwig, & Phillips, 1995, p. 430) and "systems of frenetic activity, lack of structure, unpredictability in everyday activities, and high levels of ambient stimulation" (Bronfenbrenner & Evans, 2000, p.121). It has also been described as "an environment characterized by high levels of noise, crowding, and instability as well as a lack of temporal and physical structuring (few regularities, routines, or rituals; nothing has its time or place)" (Wachs & Evans, 2010, p. 5). Despite varying descriptions, all definitions of household chaos highlight that it is characterized by two dimensions: disorganization and instability. Indices of disorganization include clutter, ambient noise, crowding and lack of structure; and instability refers to frequent changes in residence, residents (e.g. primary or secondary caregivers) and unpredictable routines (Brooks-Gunn, Johnson, & Leventhal, 2010; Wachs & Evans, 2010).

Most studies have assessed household chaos via parental report using the Confusion, Hubbub, and Order Scale (CHAOS; Matheny, Wachs, Ludwig, & Phillips, 1995). Others use specific variables within a single dimension of household chaos, either disorganization or instability. For example, elements of household disorganization, such as ambient noise and crowding have been extensively explored in the literature as these

factors are likely to be experienced on a daily basis for families (Blankson, O'Brien, Leerkes, Calkins, & Marcovitch, 2015; Evans et al., 2010; Lillard, Drell, Richey, Boguszewski, & Smith, 2015). Similarly, familial stability is an important indicator of the quality of a child's home (Ackerman, Kogos, Youngstrom, Schoff, & Izard, 1999) and thus can greatly impact child development. Although not experienced as frequently by families, even minimal exposure to indices of instability during early and middle childhood can have significant effects on behavioural functioning (Fomby & Cherlin, 2007; Tiesler et al., 2013) and a growing number of studies are examining its effects (Cooper, Osborne, Beck, & McLanahan, 2011; Schmitt, Finders, & McClelland, 2015; Ziol-Guest & Mckenna, 2014). Finally, given potential differential effects of the dimensions, some studies have measured them concurrently in relation to child and parent outcomes (Berry et al., 2016; Garrett-Peters et al., 2016; Martin, Razza, & Brooks-Gunn, 2012; Vernon-Feagans, Willoughby, & Garrett-Peters, 2016) or have combined measures of both as an index (Brown, Ackerman, & Moore, 2013; Evans, Gonnella, Marcynyszyn, Gentile, & Salpekar, 2005). Both elements contribute to the unpredictability, irregularity and confusion within the household that can impact both parenting and child outcomes and therefore, this dissertation involves examination of both direct and indirect effects of each dimension on child outcomes.

1.2.b. Adverse Effects of Household Chaos on Parenting and Child Outcomes

According to the bioecological theory, proximal processes are effective in promoting competent outcomes when they are consistent, progressively complex, reciprocal and occur over extended periods of time (Bronfenbrenner & Morris, 1998;

Bronfenbrenner & Evans, 2000). Chaotic environments disrupt the sustainability and predictability of these proximal processes thereby threatening child development (Bronfenbrenner & Evans, 2000; Wachs & Evans, 2010). As detailed below, the effects of household chaos on children and families are widespread.

Household chaos may impact child developmental outcomes through two main pathways – a direct route or indirectly via parenting. The direct path suggests that a child exposed to an uncontrolled environment may develop strategies to filter out the excess stimulation which may also prevent them from benefiting from positive environmental influences (Evans, Kliewer, & Martin, 1991). Younger children who do not have the capacity to regulate their attention may be unable to filter out irrelevant stimuli which may consequently be overwhelming and distracting and further threaten these regulatory systems (Lillard et al., 2015; Wachs & Evans, 2010). Further, cumulative chaos may interfere with a child's competency level, increasing their risk of feeling a sense of helplessness to effect change within their environment (Evans et al., 2005; White, 1959). Consequently, studies have shown significant associations between greater household chaos and deficits in child executive functioning (Hughes & Ensor, 2009), socioemotional development (Evans et al., 2005), language and literacy development (Johnson & Martin, 2008; Vernon-Feagans et al., 2012), poor academic achievement (Garrett-Peters et al., 2016), elevated psychological (Ackerman et al., 1999) and physiological (Brown, Anderson, Garnett, & Hill, 2019; Evans, Lercher, Meis, Ising, & Kofler, 2001) stress and conduct problems (Mills-Koonce, Willoughby, Garrett-Peters, Wagner, & Vernon-Feagans, 2016).

Household chaos may also influence child outcomes indirectly via its effect on caregiving. Household chaos may interfere with parent-child interactions as parents are more likely to display less responsiveness, acceptance and involvement (Vernon-Feagans et al., 2016; Wachs, 2005), lower parenting self-efficacy beliefs (Corapci & Wachs, 2002) as well as ineffective and inconsistent discipline (Dumas et al., 2005; Wachs, 2005). Further, chaotic living may lead parents to withdraw from their children due to increases in unwanted social interactions (Evans, Maxwell, & Hart, 1999). This dissertation considers both direct and indirect effects of household chaos in the examination of household chaos, parenting and child executive functioning in Study 2.

1.3 Parenting

1.3.a. Parenting Practices: An Important Proximal Process Shaping Child Development

Parenting quality has been extensively demonstrated to have an impact on child development (Sroufe, 2005) and can be considered a central proximal process in the microsystem. The effects of parent-child interactions are substantive beyond the influence of other environmental factors, particularly in the early experiences of children (Bernier, Carlson, Deschênes, & Matte-Gagné, 2012). Much of the findings are rooted in attachment models of parent-child relationships with evidence indicating that attachment security shapes child developmental trajectories (Cassidy & Shaver, 2008; Fearon, Bakermans-Kranenburg, van Ijzendoorn, Lapsley, & Roisman, 2010; Grossmann, Grossman, & Waters, 2005). Secure parent-child relationships serve as a safe base from which children can explore their interpersonal and physical environments (Ainsworth, Blehar, Waters, & Wall, 1978) and further provides the emotional and cognitive support

to promote effective exploration (Bernier, Beauchamp, Carlson, & Lalonde, 2015) and the integration of acquired skills in their developing self-regulatory processes (Calkins, 2004).

Variation in parenting practices can greatly impact physiological, socioemotional and cognitive functioning of children. For example, maternal warmth – characterized as supportive, nurturing and sensitive, has been linked to attenuated stress reactivity from infancy to later childhood (Kopp, 2009). Additionally, maternal sensitivity experienced in infancy has demonstrated strong associations with performance of impulse control in preschool aged children, particularly in low SES communities, suggesting that maternal parenting quality acts as a protective factor (Rochette & Bernier, 2014). Further, maternal sensitivity and responsiveness have been positively associated with effortful control in young children and their socioemotional functioning (Kochanska, Murray, & Harlan, 2000; Spinrad et al., 2007). In a longitudinal study, preschool children exposed to high levels of sensitivity, stimulation, positive regard, animated and engaged interactions at 36 months, exhibited fewer externalizing behaviours at 48 months (Sulik, Blair, Mills-Koonce, Berry, & Greenberg, 2015). Finally, while negative affect, criticism and control in parenting styles was negatively associated with child performance in measures of working memory, inhibition and cognitive flexibility; positive associations were found between these executive functions and parental scaffolding (Hughes & Devine, 2017).

1.3.b. Measurement of Parenting: Cognitive Sensitivity and Emotional Availability

Parenting practices may be measured via self-report scales or observational assessments. Observational assessments permit researchers to objectively identify

phenomena that may not otherwise be captured easily or validly via self-report measures (O'Connor, Matias, Futh, Tantam, & Scott, 2013; Pederson, Moran, Sitko, & Campbell, 1990). This dissertation focuses on two main measures of parenting: cognitive sensitivity and emotional availability. Cognitive sensitivity describes a caregiver's ability to effectively create a cognitively stimulating environment for another less experienced individual (e.g. child), while also responding appropriately to their affective states (Prime et al., 2015). It involves scales pertaining to: mutuality building, mind-reading, and communicative clarity (Prime, Perlman, Tackett, & Jenkins, 2014). Mutuality building refers to positively valenced turn-taking interactions, engagement in the interaction and reading and responding effectively to each other's cues (Aksan, Kochanska, & Ortmann, 2006). These interactions are particularly important for child outcomes (e.g. cognition, moral emotion and adjustment) as the child matures (Kochanska, Forman, Aksan, & Dunbar, 2005). Mind-reading, similar to mind-mindedness, describes one's sensitivity to the knowledge and ability level of their partner, and their ability to respond to subtle needs and employ strategies to better understand the other individual (Pauker, Perlman, Prime, & Jenkins, 2018; Prime et al., 2014). Communicative clarity refers to efforts to make adjustments in interactions to ensure meaningful communication (Pauker et al., 2018).

Cognitive sensitivity is based on 'thin slice methodology' (Ambady, 2010) as an alternative to otherwise costly and labour-intensive observational assessments of parenting. This methodology involves brief, impressionistic judgments of behaviour and has demonstrated good predictive validity (Ambady, 2010). Further its psychometric

properties have also been sound within developmental studies (Prime et al., 2014). Specific to mother-child dyads, the construct's factor loadings for the 11-items onto a single factor were good (.41-.88), internal consistency was excellent ($\alpha = .92$), as was inter-rater reliability ($\alpha = .84$) and the stability of maternal scores across a 1.5 year period was also significant ($r = .46$, $p < .0001$) (Prime et al., 2015). In addition to mother-child dyads (newborns to 4.5 years of age) (Prime et al., 2015), the construct has been validated across sibling interactions (Prime et al., 2014), and within early childhood education and care settings (Educator Cognitive Sensitivity scale; Pauker, Perlman, Prime, & Jenkins, 2018). Finally, the cognitive sensitivity measure has demonstrated significant association with other gold standard measures of maternal responsivity, generalizability across numerous cultural groups and significantly predicted child receptive vocabulary, theory of mind and executive functioning (Prime et al., 2015) as well as demonstrated significant negative associations with early risk factors (Browne, Leckie, Prime, Perlman, & Jenkins, 2016; Prime et al., 2015).

Emotional availability describes the establishment of an emotionally healthy relationship between caregiver and child (Biringen, Derscheid, Vliegen, Closson, & Easterbrooks, 2014). It emphasizes the importance of considering the mutual exchange which involves not only the caregivers' behaviours towards to the child in response to their cues and communications, but also the feedback the child provides in response to those behaviours. It is a multi-dimensional construct encompassing four scales for the caregiver: sensitivity, structuring, non-hostility and non-intrusiveness; and two scales for the child: responsiveness and involvement. Adult sensitivity refers to both emotional

sensitivity (i.e. emotionally calm and attune to child's cues) and behavioural sensitivity (e.g. positive and appropriately prompt responding to child) (Biringen et al., 2014). Optimal levels reflect authentic, flexible, creative, generally positive and congruent verbal and non-verbal emotional expressions. Adult structuring refers to the caregiver's ability to scaffold, empower and guide the child in their activities in a consistent way that promotes learning and encouragement for further advancement at the pace that is appropriate for the child. Adult non-intrusiveness describes behaviours that are not overly directive and support the autonomy of the child. Finally, adult non-hostility refers to the absence of both overt (e.g. angry outbursts) or covert (e.g. eye rolling) signs of hostility, boredom, impatience or anger. For the child scales: responsiveness describes the way in which the child responds to the caregiver in the interaction on an emotional (e.g. positive, genuine affect) and social (e.g. enthusiasm in response, eye contact) level. Child involvement of the adults refers to their intent in engaging the parent in the interaction via verbal (e.g. asking questions, telling a story) and non-verbal (e.g. physical proximity) communication (Biringen et al., 2014). The scales have been validated for use with children from infancy to adolescence (Biringen et al., 2010; Easterbrooks & Biringen, 2009). It has demonstrated overall acceptable reliability and validity across studies and is associated with various child outcomes including emotion regulation, and social and language development (Biringen et al., 2014). Furthermore, it has also predicted attachment categories across assessment contexts (Easterbrooks & Biringen, 2000; Easterbrooks, Bureau, & Lyons-Ruth, 2012; van den Dries, Juffer, van Ijzendoorn, Bakermans-Kranenburg, & Alink, 2012).

Parenting is a multifaceted variable that is important to consider in this dissertation for numerous reasons: 1) it is an essential proximal process that shapes multiple domains of child development, particularly during early childhood; 2) it has the capacity to protect against contextual risk factors that may threaten child development (Rochette & Bernier, 2014); however, 3) its quality can also be influenced by these contextual factors which can be to the detriment of the child; and to that point, 4) it is also associated with various characteristics and aspects of maternal functioning (e.g. mood, stress) (Choe, Olson, & Sameroff, 2013) which can affect the child as well.

1.4 Child Outcomes

In this dissertation, I focus on three main child outcomes: executive functioning (study 1 and 2), chronic stress and socioemotional functioning (study 3). Below, I provide a brief overview of each.

1.4.a. Executive Functions

Executive functions describe a collection of neurocognitive processes that are pertinent to goal directed behaviours (Diamond, 2006; Miyake et al., 2000). Three core executive functions are highlighted in the literature, inhibition, cognitive flexibility and working memory. Inhibition refers to the ability to suppress automatic or dominant responses via control over attention, thoughts, emotions and actions; cognitive flexibility describes the ability to transition between modes of mental operations, tasks or cognitive rules; and working memory refers to the active retention, manipulation and processing of information (Diamond, 2013; Miyake & Friedman, 2012; Willoughby, Wirth, & Blair, 2012). Collectively, these executive functions are needed for reasoning, planning and

problem solving (Collins & Koechlin, 2012; Lunt, Bramham, Morris, Bullock, & Selway, 2012) and are associated with numerous developmental outcomes including communication and social skills (Clark, Prior, & Kinsella, 2002), academic readiness (Blair & Raver, 2015; Brown et al., 2013), behavioural functioning (Hughes & Ensor, 2011), physical (Riggs, Spruijt-Metz, Sakuma, Chou, & Pentz, 2010) and mental health (Fairchild et al., 2009) outcomes. These effects can extend throughout the lifespan with associations to socioeconomic status, employment, physical and mental health in adulthood (Moffitt et al., 2011). This dissertation also examines effortful control and attention of children given their theoretical relevance to executive functioning (Zhou, Chen, & Main, 2012). Effortful control is multi-dimensional component of temperament, involved in self-regulation and refers to one's ability to exercise inhibition, attentional shifting, plan actions and detect errors (Rothbart, Sheese, & Posner, 2007). Attention underlies effortful control and executive functions (Zhou et al., 2012). It involves the interlinked neural networks of alerting, orienting and executive attention (Simonds, Kieras, Rueda, & Rothbart, 2007) which serve to ultimately control attention in a selective, sustained or flexible way to inform goal directed behaviours (Garon, Bryson, & Smith, 2008; Zhou et al., 2012).

During infancy and the preschool years, substantial growth in executive functioning occurs, which sets a foundation for further complex executive functions to develop throughout adolescence to adulthood (Garon et al., 2008). Development is rapid throughout childhood and is non-linear in nature (Anderson, 2002) with spurts occurring during: early childhood (ages 3-5; Carlson, 2005), middle childhood (ages 7-9),

adolescence (11- 13) and extending into early adulthood (Anderson, 2002). Further, there are slight differences in the developmental trajectories of the core executive functions. Specifically, during the first three years, there is evidence that components of executive functions are beginning to develop but have not yet reached their full capacity. For example, delaying 'instinctive' responses have been demonstrated in three-year-olds, but not without preservative errors (Espy, 1997; Garon et al., 2008) as well as holding information in mind, which is precursor to working memory (Diamond, 2013; Garon et al., 2008). Around 9 to 12 months of age, children may be able to update information in their working memory (Bell & Cuevas, 2012) but further complex manipulation of information does not develop until later (Cowan, AuBuchon, Gilchrist, Ricker, & Saults, 2011; Cowan, Saults, & Elliot, 2002; Davidson, Arnso, Anderson, & Diamond, 2006). Cognitive flexibility skills emerge around four to five years of age, where children are able to complete more complex tasks such as Dimensional Change Card Sort (Zelazo, 2006) with some evidence of children ages 3 to 3.5 years being able to complete more simplistic versions (Diamond, Carlson, & Beck, 2005; Espy, 1997). Additional improvements are seen throughout middle childhood (seven to nine years of age) and adolescence as youth demonstrate greater ability to cope with the complexity of rules, as well as show an understanding of learning from their mistakes and employing alternative strategies (Anderson, Anderson, Northam, & Taylor, 2000).

The development of executive functions are dependent on the integrity of the prefrontal cortex and are therefore, aligned with neurophysiological changes seen throughout childhood (Anderson, 2002). Brain development follows a nonlinear process

with the developmental trajectories of gray matter following an inverted U-shape – with increases during childhood (pre-puberty) followed by a decline in adolescence (post-puberty) with increased pruning and a steady increase of myelination throughout childhood and adolescence (Gied et al., 1999; Gogtay & Thompson, 2010). These changes are aligned with the lower-order sensorimotor regions along with the frontal and occipital poles maturing first, followed by a parietal to frontal maturation of the rest of the cortex (Gogtay et al., 2004). This involves integration of basic sensory regions and the protracted development of higher-order structures including the prefrontal cortex (Gied et al., 1999; Gogtay et al., 2004; Sowell, Trauner, Garnst, & Jernigan, 2002) which houses executive functioning. This protracted development increases the susceptibility of these neural structures and executive functions to the effects of early life stressors (Pechtel & Pizzagalli, 2011). This vulnerability to external factors further highlights the importance of understanding the mechanisms underlying the effects of contextual risks in order to determine effective points of entry for intervention.

Literature regarding sex differences in executive functioning in children and adolescents is mixed (Grissom & Reyes, 2018). The development of executive functions in male and female children tend to be similar, however, marginal differences have been noted. For example, male children tend to perform better in spatial reasoning and working memory tasks compared to their female counter parts (Krikorian & Bartok, 1998). Female children performed better on tasks of verbal fluency, information processing and spatial organization (Anderson, Anderson, & Garth, 2001; Brocki & Bohlin, 2004; Levin et al., 1991). Furthermore, female children outperform male children in tasks self-regulation

(i.e. attentional, inhibitory and effortful control; Else-Quest, Hyde, Goldsmith, & Van Hulle, 2006; Moilanen, Shaw, Dishion, Gardner, & Wilson, 2010; Raikes, Robinson, Bradley, Raikes, & Ayoub, 2007). Ultimately, animal and human studies suggest there may be a sex-based bias in the strategy that males and females use to approach executive functions tasks rather than in the executive functions themselves (Grissom & Reyes, 2018). More studies are needed to explore these notions and to examine whether contextual factors differentially impact executive function performance in males and females. This dissertation considers sex-based differences in the examination of the effect of household chaos on child executive functioning.

1.4.b. Hypothalamic-Pituitary-Adrenal (HPA) Axis

The hypothalamic-pituitary-adrenal (HPA) axis is one of the body's main neuroendocrine systems and one of the primary pathways of an organism's response to stress (Lupien et al., 1998). When an organism encounters a stressor, it triggers a series of reactions beginning with the release of the corticotropin-releasing hormone (CRH) and arginine vasopressin (AVP) from the paraventricular nuclei of the hypothalamus (Karl & Raith, 1966). CRH and AVP travel to the anterior pituitary and trigger the release of the adrenocorticotropin-releasing hormone (ACTH) (Stratakis & Chrousos, 1995). ACTH acts on the adrenal cortex to trigger the synthesis and release of glucocorticoids (i.e. cortisol) (Karl & Raith, 1966; Lupien et al., 1998). Cortisol travels throughout the body and brain to bind to mineralocorticoid and glucocorticoid receptors in various target tissues, including the prefrontal cortex (de Kloet, 1991; Gunnar & Quevedo, 2007). Elevated cortisol levels activate glucocorticoid receptors, which inhibit further release of

CRH and ACTH, thus halting the secretion of further cortisol through a negative feedback system in place to regulate the HPA axis activity and restore homeostasis (Lupien et al., 1998). In early childhood, regulation of HPA actively is largely determined by their social environment (Dettling, Parker, Lane, Sebanc, & Gunnar, 2000; Nachmias, Gunnar, Mangelsdorf, Parritz, & Buss, 1996) which emphasizes their vulnerability to contextual risk factors.

Chronic stress describes the repeated exposure to a stimulus in the environment that is considered to pose a threat that the individual is unable to cope with (Miller, Chen, & Zhou, 2007). Children facing chronic stress can experience allostatic overload (McEwen, 2017; McEwen & Wingfield, 2003; Miller et al., 2007) due to the continuous 'wear and tear' of the neuroendocrine and associated systems responding to prolonged stressful situations and conditions of adversity (Hostinar & Gunnar, 2013). This can lead to the dysregulation of the HPA axis which may initially present as hyperactivity of the HPA axis (McEwen, 2017), however, with persistence of the chronic stress over time this activity may reduce to levels below normal (e.g. hypoactivity) resulting in reduced cortisol output (Miller et al., 2007). This dysregulation increases their susceptibility to experiencing poor future health outcomes (Danese & McEwen, 2012; Lupien, McEwen, Gunnar, & Heim, 2009).

Most studies examining stress in childhood use saliva as a biological marker of cortisol – however this and similar biological specimens (e.g. urine, plasma) do not provide a measure of chronic stress (Short et al., 2016). These acute measures of stress are thus limited by only providing a 'snapshot' in time. Levels of cortisol in hair provide

a more chronic measure of stress by essentially averaging daily cortisol fluctuations of circulating cortisol over a period of time (typically 3 months) (Russell, Koren, Rieder, & Van Uum, 2012). Hair cortisol has been examined in relation to various child outcomes including chronic physical illness (Kornelsen, Buchan, Gonzalez, & Ferro, 2019), attention-deficit hyperactivity disorder (Pauli-Pott et al., 2017) and behavioural problems (White et al., 2017). Further, studies examining effects of socioeconomic status on child hair cortisol levels have provided some insight into the effects of contextual factors. For example, in a sample of preschool children, significant inverse associations were found between parental educational training and hair zinc levels (a marker of nutrition) and hair cortisol levels (Vaghri et al., 2013). Similarly, lower parental education and income were associated with high hair cortisol levels in parents, with the greatest effects seen for those with the most economic disadvantage (Ursache, Merz, Melvin, Meyer, & Noble, 2017). Further, parental education was negatively associated with school-aged children's hair cortisol levels above and beyond parental hair cortisol levels (Ursache et al., 2017). Associations with maternal characteristics have yielded mixed results. For example, hair cortisol levels in infants were higher for those whose mothers reported higher stress levels, but lower depression scores (Palmer et al., 2013); whereas in another study with mother-infant dyads, no significant association was found between mother or child hair cortisol levels and maternal reports of stress, affect or mood (Liu, Snidman, Leonard, Meyer, & Tronick, 2016). Few studies have examined these associations in school-aged children, in particular related to household chaos, highlighting a major gap in the literature that this dissertation aims to address.

1.4.c. Socioemotional Functioning

Socioemotional functioning refers to one's ability to successfully manage their emotions and interact with others within a social context (Peralta-Carcelen, Schwartz, & Carcelen, 2018). For the purposes of this dissertation, I will be focusing on two specific behaviour problems within the socioemotional framework: externalizing and internalizing behaviours. Externalizing behaviours describe acts of impulsivity, aggression, hyperactivity and disruption (Achenbach & Edelbrock, 1978). Internalizing behaviours refer to symptomology of depression, anxiety, somatic complaints and social withdrawal (Achenbach & Ruffle, 2000). Early proximal processes are particularly important in shaping these behavioural trajectories and the examination in the literature is vast (e.g. Degnan, Almas, & Fox, 2010; Eisenberg, Taylor, Widaman, & Spinrad, 2015; Ryan & Ollendick, 2018). Below I provide a brief summary of the associations described in the literature between my main variables of interest, household chaos and maternal distress, and externalizing and internalizing behaviour problems in children. To avoid repetition, I will only present studies not cited in sections 1.2 Household Chaos and 1.6. Maternal Distress.

Multiple studies have examined the impact of contextual risk factors such as household chaos and maternal functioning on child socioemotional functioning. For example, preschool children exposed to chaotic homes exhibited greater problem behaviours and deficits in social skills which persisted beyond the effects of poverty, child gender and parental depression (Bobbitt & Gershoff, 2016). Further, levels of familial instability also have negative effects on child behaviours. For example, a

longitudinal study that followed children from birth to fourth grade found that the cumulative experience of familial instability (i.e. changes in caregiver relationships with partners) was positively associated with greater externalizing behaviour problems (as reported by teachers), particularly if the cumulative instability was experienced prior to entering elementary school (Cavanagh, Crissey, & Raley, 2008). Similar effects are seen for children with mothers experiencing high levels of distress. One longitudinal study following children from preschool to middle childhood (i.e. ages 3 to 11 years) demonstrated that children exposed to persistent poverty and maternal depression, particularly before the age of three, exhibited higher externalizing and internalizing behaviour problems (Zilanawala, Sacker, & Kelly, 2019). Relatedly, maternal self-reported stress was significantly associated with greater externalizing and internalizing behaviours of preschool-aged children (Walker & Cheng, 2007). Given these findings, this dissertation aims to further examine the associations between maternal distress, household chaos and child socioemotional functioning.

1.5 Contributions of Poverty to Chaotic Homes

Poverty is a public health concern in Canada (Gupta, de Wit, & McKeown, 2007). Approximately 5 million (1 in 7) people live in low-income households, of which 1.2 million (nearly 1 in 4) are children and 17.8% are under the age of six (Statistics Canada, 2017). Children living in impoverished conditions face increased exposure to toxins, water and air pollutants, and inadequate nutrition (Evans, 2004; Weisner, 2010), as well as limited access to high quality resources (e.g. health care, schools, employment, libraries, public transportation, and childcare; Evans, 2004). Furthermore, these children

typically have less social support, greater exposure to violence and fewer opportunities for cognitive stimulation, and rich interactions with caregivers (Bradley & Corwyn, 2002; Brooks-Gunn & Duncan, 1997; Conger & Donnellan, 2007; Evans, 2004). These numerous factors increase the child's susceptibility to experiencing deficits in their physical health as well as cognitive, social and behavioural development (Ackerman et al., 1999; Brooks-Gunn & Duncan, 1997).

Families living within impoverished communities, also have a greater likelihood to experience chaotic households. Factors such as low-income housing, economic hardship, non-traditional work schedules, and inaccessible childcare – characteristic of low SES environments – put families at an increased risk of experiencing greater levels of chaos within their homes (Bronfenbrenner & Evans, 2000; Evans, 2004; Evans & English, 2002). For example, these children tend to experience more crowding within their homes which can trigger confusion, over-stimulation and a sense of unpredictability (Evans, Eckenrode, & Marcynyszyn, 2007; Evans, Eckenrode, & Marcynyszyn, 2010). Further noise levels can reach 5 to 10 more decibels for children living in poverty which can disrupt efforts to maintain attention (Evans et al., 2007) and is also linked to fatigue, irritability and heightened negative affect (Evans, 2006). Routines which provide structure and predictability to children may be affected by poverty as well – indeed children of higher SES are more likely to have consistent meal, nap and bedtime routines (Britto, Fuligni, & Brooks-Gunn, 2002). Further, residential and school changes as well as changes to familial structure are also more common in low SES families (Adam, 2004). These changes can interfere with the social connections and ties the child makes to

caregivers, peers and community activities which can lead to maladaptive ways of coping with the transition (e.g. increase in externalizing or internalizing behaviours). Altogether, these factors have been linked to greater risk of injuries, respiratory and cognitive development problems, and both psychological and physiological stress in children (Evans, 2004; Evans, Lercher, Meis, Ising, & Kofler, 2001). It suggests that, in some cases, chaos may be the mechanism through which poverty exerts its effects on child outcomes. It is important to note, however, that the effects of household chaos on child outcomes may also occur outside of poverty. This is based on the findings that it has been linked to child developmental outcomes in middle class samples (Hygge, Evans, & Bullinger, 2002), maintained significant associations with child outcomes with SES indices controlled for (Dumas et al., 2005) and in longitudinal studies, variations in chaos accounted for variations in developmental outcomes, with no changes observed in SES (Corapci & Wachs, 2002). As such, this dissertation will contribute to the assertion that the effects of household chaos extend across SES gradients; making it an important risk factor to target in promoting healthy child developmental trajectories.

1.6 Maternal Distress: Proposed Predictor of Household Chaos

Maternal distress is a proximal factor that plays a vital role in shaping child development. It broadly encapsulates various aspects of a mother's experiences that contribute to her overall functioning and interactions with her child including, personality characteristics, familial functioning, mood, and contextual sources of stress and supports (Belsky, 1984). As such, to present an ecological perspective of the experience of distress for mothers, a multi-dimensional construct needs to be considered (Yoo, Popp, &

Robinson, 2014). Maternal distress has been operationalized in various ways, including measures of self-reported stress and symptomology of depression and anxiety (Dubois-Comtois, Moss, Cyr, & Pascuzzo, 2013; Whitesell, Teti, Crosby, & Kim, 2015), as well as negative emotional bias (Yoo et al., 2014), relationship quality (Papp, Goeke-Morey, & Cummings, 2007), family functioning (Rafferty, Griffin, & Robokos, 2010) and life satisfaction (Doyle, Delaney, O'Farrelly, Fitzpatrick, & Daly, 2017). In this dissertation, I include measures of maternal depression, negative affect and stress physiology in my composite of maternal distress. Below, I provide a brief overview of the literature on these specific maternal indicators and the effect that these factors individually, or collectively have on child outcomes both directly and indirectly.

In this dissertation, I examine whether maternal distress, not only directly impacts child physiological stress and socioemotional outcomes, but also has an indirect association via its influence on the levels of household chaos. To date, the literature has focused primarily on the impact of contextual factors on maternal functioning. For example, studies have suggested that contextual risk factors with established links to child developmental outcomes (e.g. indices of poverty) may be out of the mother's control (Blair & Raver, 2016; Newland, Crnic, Cox, & Mills-Koonce, 2013) and can impact both her functioning, as well as her parenting practices via a sense of helplessness (Evans & Stecker, 2004) or depleted parental self-efficacy (Corapci & Wachs, 2002). Elements of chaos, greater disorganization and instability, have significant associations with elevated stress levels and reduced sensitivity in parenting (Corapci & Wachs, 2002; Deater-Deckard et al., 2009). Further, maternal psychological distress, as defined by self-reported

symptoms of depression, anxiety and somatization, mediated associations between household disorder and children's externalizing and internalizing behaviours, as well as between relationship instability (e.g. co-residential relationships that lasted at least one month) and child externalizing behaviours (Coley, Lynch, & Kull, 2015). Although household chaos may be the cause of dysregulated maternal functioning and parenting, it may also be the result of maternal distress. On the face of it, this assertion may seem counterintuitive; however, mothers likely structure many aspects of the home environment including the organization, quality and dynamics of household activities, and influence stability through relationships, consistent rules and responding and implementation of routines. A mother's capacity to structure the home environment may be compromised if mothers experience elevated levels of depressive symptoms, have increased stress and greater negative affective attributions. While this assertion is based on anecdotal evidence, to my knowledge, only one study to date has formally examined this mechanism. In this study, Hur and colleagues (2015) reported that maternal depression was positively associated with household chaos, which was associated with problem behaviours in the pre-school aged children (Hur, Buettner, & Jeon, 2015). This overall model is also supported by evidence demonstrating positive direct associations between maternal distress and poor child socioemotional functioning and stress physiology. Greater self-reported maternal stress was positively associated with increased problem behaviours in school-aged children (Crnic, Gaze, & Hoffman, 2005; Qi & Kaiser, 2003). Similar findings have been demonstrated between maternal depression and socioemotional outcomes (e.g. Goodman et al., 2011). Further, maternal depression and

stress have also been significantly linked to elevated waking cortisol levels in children, which is considered a marker of risk for future depressive symptomology (Ashman, Dawson, Panagiotides, Yamada, & Wilkinson, 2002; Dougherty, Klein, Olino, Dyson, & Rose, 2009; Essex, Klein, Cho, & Kalin, 2002). Ultimately, in my third paper, I argue that maternal distress is another plausible risk factor to proximal processes within the home environment that can have widespread, direct and indirect effects on child socioemotional and stress physiology outcomes via chaos levels in the home.

1.7 Dissertation Objectives

Household chaos poses a threat to healthy child development with specific implications for child cognitive, physiological and socioemotional outcomes. These effects can occur both directly, as well as indirectly via disrupting caregiver behaviours that would otherwise protect the child from contextual risk factors. Further, little is known regarding factors that predict levels of chaos in the home beyond SES indices, although our understanding of this serves as a valuable point of entry for preventative programs for children and families. This dissertation proposes maternal distress as a viable factor in influencing levels of chaos of the home. With the theoretical support of the bioecological theory of human development, as well as the growing empirical evidence of the impact of household chaos on child outcomes, this dissertation seeks to examine the direct and indirect effects of household chaos on various domains of child functioning, as well as examine the potential mediating role that parenting plays and the proposed predictive contribution maternal distress makes in explaining levels of chaos in the home. The first study examines the direct effects of household chaos on child

executive functioning via meta-analytic techniques. I hypothesize that small to moderate effect sizes will be derived from a synthesis of studies and indices of SES will moderate this association. In the second study, I hypothesize that both direct and indirect effects (via parenting) of household chaos will be demonstrated on child executive functioning. Specifically, greater levels of chaos will be associated with lower cognitive sensitivity and emotional availability which will be associated with lower performance on executive functioning tasks. Further, a direct, inverse association will also be demonstrated between household chaos and child executive functioning. Finally, for the third study, I hypothesize that high levels of maternal distress as measured by depression, stress physiology and negative affect, will be associated with greater levels of household chaos which will be associated with higher levels of hair cortisol concentration, as well as elevated externalizing and internalizing behaviours. Further, I also hypothesize that direct positive associations will also be demonstrated between maternal distress and child hair cortisol levels and socioemotional outcomes.

Chapter 2: Study 1

General Purpose

Household chaos has been linked to deficits in executive functioning in children (Dumas et al., 2005; Hughes & Ensor, 2009) as well as effortful control (Chen, Deater-Deckard, & Bell, 2014) and attention (Brown, Weatherholt, & Burns, 2010). The effects are diffuse with implications for numerous developmental outcomes essential to the overall functioning of the child such as communication and social skills (Clark et al., 2002), behavioural functioning (Sulik et al., 2015) and academic readiness (Blair & Raver, 2015). However, no study to date has examined the association between household chaos and child executive functioning through a quantitative synthesis of findings, which is important given the variation of effect across studies. Thus, the first objective of this dissertation is to examine the magnitude of effect between household chaos and child executive functioning, examine the interaction between household chaos and the measurement approach of executive functions (i.e. informant completed questionnaires versus direct assessment), and to identify potential factors that may influence this association (e.g. child age, sex, race/ethnicity).

Title and Authorship

Title: Examining the effects of household chaos on child executive functions: A meta-analysis

Authors: Andrews, K., Atkinson, L., Harris, M., Gonzalez, A.

Conflicts of Interest: None

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Abstract

Household chaos – characterized by disorganization and instability within the home – is inversely associated with child executive functioning, though a quantitative synthesis of the findings is lacking. The meta-analyses presented here incorporate 26 studies with 27 independent effect sizes including 8,944 children. Several moderators were assessed, the most fundamental involving method (i.e., informant-completed questionnaire versus direct assessment) of assessing executive functions. The analyses revealed a significant overall effect of r = .22. Only measurement approach of executive functions significantly moderated this association: informant-completed questionnaires yielded an effect of r = .27, as compared to direct assessment, r = .16, although both effects were significant. Based on substantive and statistical considerations, questionnaire and direct assessment effects were then meta-analyzed separately. Although effect sizes proved heterogeneous in the context of questionnaires, analyses revealed no significant moderators. Within direct assessment effects, both household chaos dimensions proved significantly related to child executive functions, but instability was a stronger correlate (r = .21) than disorganization (r = .09). Composition of sample also moderated effect; effects increased with the proportion of minorities and parents with less educational training. Results highlight the need for fuller investigation of differences in construct measurement presented by questionnaire and direct assessment approaches to child executive functions. At present, it appears prudent to adopt a multi-method approach to assessment. Furthermore, greater focus on the mechanisms by which events and familial demographics differentially destabilize child executive functions is essential to a better

understanding of the relation between environmental features and child cognitive function.

Introduction

Household chaos is described as "systems of frenetic activity, lack of structure, unpredictability in everyday activities, and high levels of ambient stimulation" (Bronfenbrenner & Evans, 2000, p.121). It is characterized by two broad features: disorganization and instability. Indices of disorganization include: clutter, ambient noise, crowding and lack of structure (Matheny, Wachs, Ludwig, & Phillips, 1995; Sameroff, 2010). Instability refers to frequent changes in residence, residents (e.g. primary or secondary caregivers) and a lack of or unpredictable routines (Wachs & Evans, 2010). Household chaos disrupts the development and sustainability of the experiences of the child within their home (e.g. relationships, activities, routines; Bronfenbrenner & Evans, 2000; Evans, Gonnella, Marcynyszyn, Gentile, & Salpekar, 2005). This is particularly detrimental for younger children, where one's immediate built environment is important for early establishment of core capacities (Dunn, 2012; Oliver, Dunn, Kohen, & Hertzman, 2007). As such, household chaos is adversely associated with numerous child and adolescent outcomes including deficits in socioemotional development (Evans et al., 2005; Fiese & Winter, 2010), poor language and early literacy development (Johnson,Martin, Brooks-Gunn, & Petrill, 2008; Vernon-Feagans et al., 2012), lower intelligence levels (Deater-Deckard et al., 2009), deficits in academic achievement (Garrett-Peters et al., 2016), and conduct problems and callous-unemotional behaviours (Mills-Koonce, Willoughby, Garrett-Peters, Wagner, & Vernon-Feagans, 2016). Relevant to this review, higher household chaos has also been linked to deficits in executive functions (Berry et al., 2016; Hughes & Ensor, 2009), with many, but not all studies

showing significant associations. Although findings are mostly consistent, there is variation across studies, with few identifying reliable moderators. No study to date has formally integrated these findings and examined the interaction between household chaos and the approach adopted in measuring executive functions (i.e. informant-completed questionnaires versus direct assessment). Nor have studies systematically evaluated the influence of potential moderators (e.g., disorganization versus instability, child gender, age, race/ethnicity). The present meta-analysis assesses the strength of association between household chaos and child executive functions and examines potential moderators of this association.

Child Executive Functions

Executive function is an umbrella term for higher order cognitive processes subsumed by the prefrontal cortex (Diamond, 2013; Miyake et al., 2000) and is critical to flexibility, planning and goal directed behaviour (Miyake & Friedman, 2012). Based on theoretical considerations (Diamond, 2013; Zhou, Chen, & Main, 2012), and given that many studies assess these constructs in children, the current meta-analysis includes inhibition, cognitive flexibility, working memory, effortful control and attention as measures of child executive function. *Inhibition* refers to the ability to suppress automatic or dominant responses via control over attention, thoughts, emotions and actions (Diamond, 2013). *Cognitive flexibility* or *set-shifting* describes the ability to transition between modes of mental operations, tasks or cognitive rules (Miyake et al., 2000; Willoughby, Wirth, & Blair, 2012). *Working memory* refers to the active retention, manipulation and processing of information (Willoughby et al., 2012). *Effortful control* is

a component of temperament and refers to the ability to regulate one's behaviour via inhibitory control, planning actions, detecting and correcting errors, resolving conflict as well as shifting attention (Diamond, 2013; Rothbart, Sheese, & Posner, 2007). Lastly, *attention* is comprised of three interlinked neural networks (alerting, orienting and executive attention) and is also inherent to effortful control (Rothbart & Rueda, 2005; Simonds, Kieras, Rueda, & Rothbart, 2007). Inclusion of this core set of executive functions is important to a robust assessment of the extensive effects of household chaos documented in the literature.

Household Chaos and Child Executive Functions

Direct associations have been made between higher household chaos and poor performance in tasks related to core executive functions (inhibitory control, cognitive flexibility, working memory; Hughes & Ensor, 2009; Hur, Buettner, & Jeon, 2015), as well as attention (Brown, Weatherhold, & Burns, 2010), and effortful control (Chen, Deater-Deckard, & Bell, 2014). Notably, due to its broad definition, household chaos is operationalized in various ways both within and across studies. There is similar variation in the measurement approach of executive functions using either questionnaires (e.g., Behavior Rating Inventory of Executive Function (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000)) or direct assessments (e.g. Dimensional Change Card Sort (DCCS; Zelazo, 2006)). Consequently, while associations between household chaos and child executive functioning have been demonstrated, effect sizes vary widely. As such, the definition of household chaos and the measurement of executive functions have important implications for this meta-analysis and, therefore, serve as important moderators in

examining this association. Other potentially important moderators are also assessed as described below (i.e. hot vs. cool executive functions, child age, SES indices, child gender and temporal characteristics).

Household chaos dimension

Studies have examined the differential effects of the two dimensions of household chaos, disorganization and instability, on child executive functions. Household disorganization has been found to negatively influence inhibitory control, attention shifting and working memory (Berry et al., 2016). Similarly, greater household instability (e.g. caregiver structure changes, residential mobility, job/income loss, familial death) has been associated with more difficulties with effortful control in children from ages four to six years (Sturge-Apple, Davies, Cicchetti, Hentges, & Coe, 2017). Furthermore, a lack of routine in early childhood has been linked to poor performance on delayed gratification tasks at school-age (Martin, Razza, & Brooks-Gunn, 2012). Though recognized as two separate dimensions, correlations between disorganization and instability are rarely examined, although authors of the Family Life Project have reported correlations of approximately $r = .4$ (Garrett-Peters et al., 2016; Vernon-Feagans, Willoughby, & Garrett-Peters, 2016). Although significant, each dimension also accounts for unique (non-shared) variance. Given the theoretical importance of these two dimensions, potential differential effects of instability and disorganization were examined as a moderator.

Measurement of Executive Functions

Executive functions of young children can be measured via empirically validated questionnaires and/or direct assessments. Questionnaires, such as the BRIEF (Gioia, Isquith, Guy, & Kenworthy, 2000), are typically completed by parents or teachers and are related to children's abilities in navigating home and school contexts. These questionnaires aim to assess a number of executive function domains including working memory, inhibition, set-shifting and emotional control. Direct assessments, for example the DCCS (Zelazo, 2006), are typically completed by the child within highly standardized conditions with each task designed to measure one or more specific executive function. Low correlations between direct assessment and questionnaires are common (Anderson, Anderson, Northam, Jacobs, & Mikiewicz, 2002; Mahone et al., 2002), suggesting that their shared variance is limited. A systematic review of thirteen studies focusing on child and adolescent populations (with the exception of one study looking at young adults), assessed the BRIEF against direct assessments (Toplak, West, & Stanovich, 2013). Of the correlations reported in these studies, the mean *r* was .15 and only 19% were significant. A more recent study provided similar results; aside from working memory, the scales on the BRIEF did not significantly correlate with their corresponding direct assessment tasks (Krivitzky, Bosenbark, Ichord, Jastrzab, & Billinghurst, 2019). Further, these low correlations extend to other child executive function questionnaires (range across scales, *r* = .01 to -.15, *ns*; Emslie, Wilson, Burden, Nimmo-Smith, & Wilson, 2003; Roy, Allain, Roulin, Fournet, & Le Gall, 2015). Given these findings, it is possible that questionnaires and direct assessments measure distinct domains of executive functioning. While direct

assessments may detect the processing efficiency of executive functions in children during highly structured tasks, questionnaires may provide a more ecologically valid perspective in measuring rational goal pursuit (Toplak et al., 2013). Furthermore, these approaches may also differ in their association with other neurodevelopmental processes. For example, while both questionnaires and direct assessment predicted reading and mathematical ability in school-aged children; they differed in their capacity to predict attention and motor ability (Ten Eycke & Dewey, 2016). Questionnaires significantly predicted measures of attention, such that lower executive function ability predicted higher attention problems, whereas the direct assessment significantly predicted measures of motor ability, such that higher executive function ability predicted better motor ability.

These findings are further supported by research suggesting that questionnaires and direct assessments may have differing underlying neurobiological substrates. One study showed that, for working memory, there was no association between questionnaires and lobar volumes, however, direct assessments were negatively correlated with the volume of the right hippocampal lobe (Faridi et al., 2015). Additionally, negative correlations were found between questionnaires and bilateral cortical thickness of the posterior parahippocampal gyrus (PG); whereas no such associations were found with tests of direct assessment. Collectively these findings highlight the importance of analyzing the two methodological approaches separately.

Hot and Cool Executive Functions

Executive functions can be categorized as ‘hot’ or ‘cool’. Hot executive functions (e.g., inhibition, effortful control) encompass affective and motivational aspects of

cognition. They are underpinned by the ventral and medial regions of the prefrontal cortex, as well as mesolimbic reward circuitry (e.g. amygdala and striatum) (Zelazo & Muller, 2002). Cool executive functions (e.g. working memory, cognitive flexibility), are considered 'purely' cognitive as they involve abstract thinking and decontextualizing problems and are associated with the dorsolateral prefrontal cortex (Zelazo & Muller, 2002). Arguments towards the distinction between the two types of executive function is supported by human and nonhuman lesion studies, with deficits in hot executive functions occurring independently of deficits in cool executive functions and vice versa (Zelazo & Carlson, 2012). Conversely, others have suggested that hot and cool skills are integrated (Allan & Lonigan, 2011; Aron, Robbins, & Poldrack, 2004). Given these varied findings, the proportion of hot executive function tasks used within studies was included as a moderator as a means of assessing the relative impact of household chaos on hot and cool executive functions.

Development of Executive Functions

Basic components of executive functions (e.g. delayed response or holding information in one's mind) emerge within the first three years of life, with attention underlying this stage of development (Garon, Bryson, & Smith, 2008; Garon, Smith, & Bryson, 2014). Maturation toward more complex executive functions (e.g. development of inhibition, working memory, set-shifting) occurs in a stepwise fashion with key developmental periods occurring in early childhood (ages 3-5; Carlson, 2005), middle childhood (ages 7-9), and extending throughout adolescence into early adulthood (Anderson, 2002). Neuroimaging studies have corroborated neuropsychological changes

underlying this stepwise development. Maturation of cortical structures (e.g. gray matter loss; pruning) are aligned with major developmental milestones (e.g. cognitive, functional) across childhood and adolescence (Gogtay et al., 2004) through to early adulthood (Diamond, 2006; Pechtel & Pizzagalli, 2011). This prolonged development leaves executive functions vulnerable to the detrimental effects of early adversity, that may last beyond cessation of the adverse factors (Pechtel & Pizzagalli, 2011). Given developmental and neural trajectories underlying executive functions across childhood through to adulthood, child age was evaluated as a moderator.

Sociodemographic Effects on Executive Functions

Sociodemographic factors (e.g., income, parental education, racial/ethnic status) are related to individual differences in executive functions and have been extensively explored in the literature with consistent trends towards low SES and difficulties in child executive functioning (Holochwost et al., 2016; Lawson, Hook, & Farah, 2017; Raver, Blair, Willoughby, & The Family Life Project Key Investigators, 2013). Although household chaos can occur within higher SES homes, many indicators of poverty such as low-income housing, non-traditional work schedules, and inaccessible childcare, put families at greater risk of experiencing household chaos (Evans, Eckenrode, & Marcynyszyn, 2010; Lichter & Wethington, 2010). In fact, early, cumulative household chaos mediates the association between indicators of poverty and child (Dumas et al., 2005) and adolescent (Evans et al., 2005) socioemotional outcomes. As such, household chaos is an important mechanism through which poverty can exert its effects on children above and beyond other demographic (e.g. parental education), familial (e.g. parenting)

and early cognitive abilities (Garrett-Peters et al., 2016). Thus, we considered the moderating effect of two proxies of SES (e.g. parental education, racial/ethnic status) on the association between household chaos and child executive functions.

Sex Differences in Executive Functions

While development of executive functions is similar in males and females, marginal differences have been noted in spatial reasoning and working memory (males outperformed females) (Krikorian & Bartok, 1998) and verbal fluency, information processing and spatial organization (females outperformed males; Anderson, Anderson, & Garth, 2001; Brocki & Bohlin, 2004; Levin et al., 1991). Other studies have demonstrated that females outperform males in measures of self-regulation (i.e. attentional, inhibitory, and effortful control) as well (Else-Quest, Hyde, Goldsmith, & Van Hulle, 2006; Moilanen, Shaw, Dishion, Gardner, & Wilson, 2010; Raikes, Robinson, Bradley, Raikes, & Ayoub, 2007). Thus, the sex of the child may play an important moderating role in the relationship between chaos and executive function.

Temporal Characteristics

The further the assessments are from one another, the smaller their correlation may be, due to time-related intervening factors (e.g., Atkinson et al., 2000). Thus, temporal distance between household chaos and child executive function assessments was assessed as a moderator.

The Current Study

The aim of the current study is three-fold: 1) to examine the magnitude of effect between household chaos and executive functions in children; 2) to examine potential

moderators that influence the association between household chaos and executive functions; and 3) to identify gaps within the household chaos and executive functions literature.

Methods

Operational Definitions

The aim of the current meta-analysis was to synthesize the literature examining the association between household chaos and child executive functioning. As such, this review considered the findings on household chaos in their entirety. Studies which measured one or both dimensions of household chaos (disorganization and instability) were included. Elements of disorganization included: crowding/density, clutter, lack of structure and ambient noise (e.g. neighbourhood or TV noise) (Sameroff, 2010); while instability referred to changes in residences, changes in primary or secondary caregivers, and a lack of or unpredictable routines (Wachs & Evans, 2010). Studies that incorporated household chaos as a component of a larger construct of socioeconomic status were considered if they presented data on household chaos distinct from the overall construct. To account for the varied executive function assessment methods, both informant-completed questionnaires and direct assessment measures were included. Direct assessment tasks that measured core executive functions included: working memory (e.g. Digit Span; Wechsler, 2014), cognitive flexibility (e.g. DCCS; Zelazo, 2006) and inhibition (e.g. Day-Night Stroop; Gerstadt, Hong, & Diamond, 1994). Measures of attention and effortful control were also included. Questionnaires, such as the BRIEF (Gioia et al., 2000), were also included.

Literature Review

A comprehensive search was conducted of the following databases: Medline, EMBASE, PsycINFO, ERIC, PubMed and ProQuest Dissertations & Theses A&I covering all studies from inception of the database to April 2019. Relevant key search terms were categorized under three primary variables. To capture data for household chaos: home*, house*, famil*, residen* and environment* were used in conjunction with: chaos, disorgan*, disorder*, instabilit*, crowd*, dysfunc*, and unpredict*. Executive function was examined via: executive control*, executive process*, effortful control, inhibit*, impuls*, executive attent*, attent*, working memory, set-shift*, and cognitive flexibilit*. Participants were narrowed to children and adolescents with the following terms: child*, girl*, boy*, infant*, toddler*, pre-school*, young person*, minor*, teen*, adolescen*, youth*, school-aged, and early childhood*. Bibliographies from relevant reviews and book chapters were manually searched for additional citations.

Inclusion Criteria

The following inclusion criteria were applied: 1) sample consisted of children and/or adolescents (aged 2 to 17 years); 2) studies included a measure of one or more dimensions of household chaos (e.g. disorganization and/or instability) distinct from other related constructs (e.g. indices of SES); 3) studies included at least one measure of executive function as a correlate of household chaos, including informant-completed questionnaires and direct assessments; and 4) articles were written in the English language.

Selection of Studies

Figure 1 shows the process of selection and exclusion of articles. The initial search yielded 9608 non-duplicate studies. After titles and abstracts were screened to determine relevance, 231 articles remained. Full text review of these articles resulted in elimination of an additional 195 articles. The remaining 36 articles underwent data extraction during which an additional seven were removed due to overlapping study samples; in such cases, the study with the largest sample size was selected. Three additional articles were not included in the main analysis due to inclusion of covariates or lack of relevant statistics. Two independent reviewers (KA, MH) conducted screens of articles at each stage. Disagreements between reviewers were resolved via an in-depth discussion and thorough review of relevant sections of the articles in question. Interrater reliability was established by coding 10% articles at the title and abstract screen, 20% at the full text screen and 100% at data extraction. Percent agreement was greater than 80% at each stage (*kappa* = .769 ($p<.0001$)). To address insufficient moderator data, 25 authors were contacted via email. Of those contacted, seven authors responded and provided the requested information, eight authors responded and did not have the requested information (e.g. not measured, no longer have access to data), one declined to provide requested information, and no response was received from the remaining nine authors. Final consensus between reviewers resulted in 26 articles (27 data sets) included in the meta-analysis.

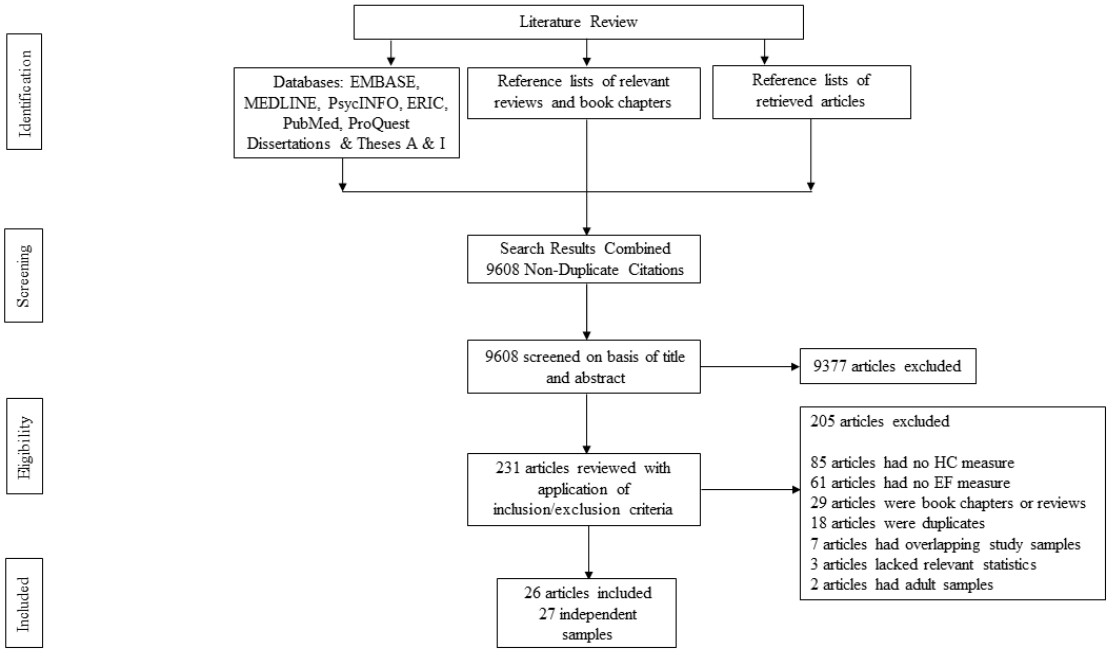

Figure 1. Flow chart of study selection process for meta-analysis on household chaos and child executive function literature.

Coding

A single Pearson correlation (*r*) between measures of household chaos and executive functions was entered for each sample. Valence of each correlation was adjusted to account for the direction of effect. Effect sizes indicating a negative correlation between household chaos and executive functions were considered positive (i.e. higher household chaos linked to lower executive functions performance), representing the expected direction of association. One study provided correlational values via a bar graph (Hughes & Ensor, 2009), however, the value was extracted using the Web Plot Digitizer program (Rohatgi, 2018). Three studies were excluded from the

meta-analysis (k = 27), but in each case an r of 0.0 was imputed (Rosenthal, 1995) and entered into a sensitivity analysis (k =30) to assess robustness of effect size parameters.

Two independent reviewers coded the moderator information for each article including: (a) household chaos dimension (disorganization versus instability); (b) percentage of 'hot' executive function tasks (measures of inhibition and effortful control); (c) sex composition of sample (percentage of female children); (d) mean child age in years at time that executive function was measured; (e) race/ethnicity (percentage of minorities in sample); (f) parental education (percentage of parents with less than or equal to a high school diploma or General Educational Development (GED); and (g) months between assessments of household chaos and child executive function.

For the purposes of this review, studies that used the Confusion, Hubbub and Order scale (CHAOS) were coded as disorganization which is aligned with the elements (e.g. noise, crowding) used in the scale's original development (Matheny et al., 1995). Three studies composited disorganization and instability measures (Berry et al., 2016; Brown et al., 2013; Evans et al., 2005), with only one providing separate effect sizes of each measure with executive function (Berry et al., 2016). As such, data regarding household chaos dimension for the other two studies were considered missing and not included in the moderation analysis. In one instance (e.g. Berry et al., 2016), an *a priori* decision was made to select the correlation between instability and child executive functions to ensure comparability of cell sizes. For child age, where multiple measures were administered across time (both within and across studies), the age at which assessments of household chaos and executive functioning were most proximal was

chosen. One study (Burney, 2010) reported an age range, and using a pre-established method (Wan, Wang, Liu, & Tong, 2014) the sample mean age and standard deviation were estimated.

Interrater Reliability: Effect Sizes & Moderators

Interrater reliability analyses were conducted to establish consistency in coding of effect sizes and moderators by two independent raters (KA, MH). For effect sizes and sample sizes, interrater reliability was ICC (3, 1) = .810 and ICC (3, 1) = .988 respectively. Reliability for moderator data were as follows: (a) household chaos dimension (*kappa* = 1.0 ($p<.0001$)), (b) percentage of 'hot' executive function tasks (*kappa* = .780 ($p<.0001$)), (c) sex composition (ICC (3, 1) = .998), (d) child age (ICC (3, 1) = .872), (e) race/ethnicity composition (ICC (3, 1) = .993), (f) parental education (ICC (3, 1) = .855), and (g) time between assessments of household chaos and child executive function (ICC (3, 1) = .817).

Analytical Strategy

The Comprehensive Meta-Analysis (CMA, Version 3.0) software program (Borenstein, Hedges, Higgins, & Rothstein, 2013) was used to calculate effects. Summary effect sizes were calculated as correlation coefficients (*r*) within a random effects model. Effect sizes were inversely weighted according to their variance to minimize upward-biased effects of smaller studies and thus produce more accurate overall effect size estimates (Hedges & Olkin, 1985). The CMA software was also used to compute within study effect size composites based on multiple outcomes, tests of heterogeneity, proportion of between-sample variance, moderation, and publication bias.

Notably, three meta-analyses were conducted in the current study. The initial overall meta-analysis included all datasets (k =27), regardless of measurement approach. In this analysis, four studies used both questionnaires and direct assessment to assess executive functioning (Gaertner, Spinrad, & Eisenberg, 2012; Lanza & Drabick, 2011; Brown et al., 2019; Rea-Sandin, 2018). The four effect sizes pertaining to informant-completed questionnaires were removed to ensure sample independence in the comparison of questionnaire and direct assessment effects and to ensure equal representation of effect sizes across measurement approach. Subsequent to this initial overall analysis, independent analyses were conducted on each of the informant-completed questionnaire and direct assessment data sets. For these separate analyses, the four effect sizes previously removed were re-inserted into the questionnaire analysis ensuring maximal use of the data and augmented moderation analysis for factors other than measurement approach. The total number of samples in the questionnaire and the direct assessment analyses was 17 and 14, respectively.

Statistical Independence

For each study, the effect size (r) was calculated as the correlation between household chaos and executive functions. In most instances, datasets only had a single measure of executive function (k=13); in others, authors provided a composite of executive function measures (k=3). Some datasets provided correlations between household chaos and each subscale of a single measure (k = 3), or multiple executive functions tasks (k = 7). These cases required the extraction of the correlation between household chaos and each subscale or executive function measure as well as the inter-

correlations amongst subscales or executive function measures (provided in the studies) in order to compute one effect size per dataset via procedures previously outlined (Borenstein, Hedges, Higgins, & Rothstein, 2009). Similarly, while most studies provided a single measure of household chaos, one study (Vrijhof, van der Voort, van IJzendoorn, & Euser, 2018) provided multiple measures of household disorganization, each with a correlate for executive function. In this case, a single effect size was generated by statistically combining the correlates via the aforementioned strategy (Borenstein et al., 2009).

Tests of Heterogeneity and True Between-Sample Variance

Heterogeneity of the overall set of effect sizes was tested via computation of the *Q* and the I^2 statistics (Borenstein, Hedges, Higgins, & Rothstein, 2009). The *Q* statistic provides a ratio of observed variation to within study variation of the effect sizes (Borenstein et al., 2009). The I^2 statistic is an estimate of the proportion of variance that is due to real population differences (Borenstein et al., 2009; Higgins, Thompson, Deeks, & Altman, 2003).

Moderator Analyses

To assess for moderation, *Q*-statistics were calculated in the case of categorical variables (i.e. household chaos dimension). For dimensional moderators (i.e. proportion of hot executive function tasks, sample sex composition, mean child age, racial/ethnic sample composition, parental education, and temporal distance between household chaos and executive function measurements), meta-regression was employed, using a method of moments approach. This is a conservative method which makes no assumptions regarding

distribution properties. As per a previously established convention (Borenstein et al., 2009), analyses involving categorical variables were only conducted for moderators with five or more observations per cell so as to ensure viable estimates of between-sample variance.

Publication Bias

Potential publication bias was assessed using funnel plots of the effect sizes against their standard error. Additionally, Duval and Tweedie's (2000a, 2000b) 'trim and fill' method, based on the symmetry of the funnel plots, was used to impute the possible existence and impact of unpublished studies (Borenstein et al., 2009). This included derivation of an adjusted overall effect size and confidence interval.

Results

Study characteristics

Characteristics of the studies included in this meta-analysis are outlined in Table 1. A total of 26 articles, including 27 independent samples, and 8944 participants, are represented in the analysis. Of the 27 samples, 22 were represented in published articles and 5 were part of unpublished dissertations. Years of publication ranged from 2005 to 2019. Studies were predominantly conducted in the United States (23), while remaining studies were conducted in the Netherlands, the United Kingdom and Australia.

Table 1.

Overview of studies included in meta-analysis

Study Authors	N (analytic sample)	Year	Location of Study	Sex Composition (% female)	Racial/Ethnic Composition of Sample	Child Age (years)	Parental Education	HC Measure	EF Measure	Measurement Approach of EF	Hot (vs. Cool) EF
Berry et al.	1235	2016	United States	50	73	4.0	NR	*Indices of household disorganization and instability	Silly Sounds Stroop; Animal Go/No-Go; Spatial Conflict Arrows; Working Memory Span; Pick the Picture Game; Something's the Same Game	DA	50
Brieant et al.	157	2017	United States	47	20	14.1	35	CHAOS Scale	Stanford-Binet Memory for Digits; Wisconsin Card Sorting Test; Multi-Source Interference Task	DA	33

Table 1.

(continued)

Study Authors	N (analytic sample)	Year	Location of Study	Sex Composition (% female)	Racial/Ethnic Composition of Sample	Child Age (years)	Parental Education	HC Measure	EF Measure	Measurement Approach of EF	Hot (vs. Cool) EF
Brown, Weatherholt et al.	123	2010	United States	54	90	5.6	52	CHAOS Scale	DA: Spatial Orientation of Attention; Alerting Task; Executive Attention task; ICQ: Child Behaviour Questionnaire; ADHD Index	DA and ICQ	0
Brown, Ackerman et al.	120	2013	United States	51	90	4.2	44	CHAOS Scale and residential instability: number of changes in where and/or with whom children had lived since their birth	Day-Night Stroop Task; Peg Tapping task; Bear/Dragon task	DA	75
Burney	190	2010	United States	50	26	4.5	10	CHAOS Scale	Child Behaviour Questionnaire	ICQ	100

Table 1.

(continued)

Study Authors	N (analytic sample)	Year	Location of Study	Sex Composition (% female)	Racial/Ethnic Composition of Sample	Child Age (years)	Parental Education	HC Measure	EF Measure	Measurement Approach of EF	Hot (vs. Cool) EF
Chen et al 2014	149	2014	United States	50	22	4.8	31	CHAOS Scale	Child Behaviour Questionnaire	ICQ	100
Dumas et al.	106	2005	United States	50	14	5.7	NR	CHAOS Scale	Child Behaviour Questionnaire	ICQ	50
Evans et al.	223	2005	United States	48	6	13.1	NR	CHAOS Scale & items from Family Rituals Questionnaire and Family Routines Inventory	Children's Self-Control Scale	ICQ	100
Gaertner	230	2012	United States	44	15	2.5	17	CHAOS Scale	DA: Dinky Toys; Gift Delay; Rabbit & Turtle; ICQ: Early Childhood Behaviour Questionnaire; Infant Behaviour Record	DA and ICQ	100
Gould et al.	1040	2018	Australia	52	NR	9.4	NR	CHAOS Scale	Strengths and Weaknesses of ADHD Symptoms and Normal behavior subscales: Inattention, Hyperactive/Impulsive	ICQ	50

Table 1.

(continued)

Study Authors	N (analytic sample)	Year	Location of Study	Sex Composition (% female)	Racial/Ethnic Composition of Sample	Child Age (years)	Parental Education	HC Measure	EF Measure	Measurement Approach of EF	Hot (vs. Cool) EF
Hardaway et al.	659	2012	United States	49	50	3.0	41	CHAOS Scale	Child Behaviour Questionnaire and Behavioural Attention Styles	ICQ	50
Hughes et al.	125	2009	United Kingdom	38	4	4.0	72	CHAOS Scale	Baby Stroop task, Trucks task, Beads task, Tower of London task	DA	25
Hur et al.	444	2015	United States	47	39	4.6	NR	CHAOS Scale	Head-Toe-Knee-Shoulder task	DA	33
Kraft et al.	69	2014	United States	30	NR	3.6	NR	CHAOS Scale	Child Behaviour Questionnaire-Short Form	ICQ	100
Lanza et al.	87	2011	United States	49	100	7.8	77	Child Puppet Interview	DA: Intra/Extra Dimensional (IED) Set Shift subtest (Cambridge Neuropsychological Test Automated Battery (CANTAB)); ICQ: Child Symptom Inventory	DA and ICQ	0

Table 1.

(*continued*)

Study Authors	N (analytic sample)	Year	Location of Study	Sex Composition (% female)	Racial/Ethnic Composition of Sample	Child Age (years)	Parental Education	HC Measure	EF Measure	Measurement Approach of EF	Hot (vs. Cool) EF
Lemery-Chalfant et al.	807	2013	United States	49	10	7.9	NR	CHAOS Scale	Child Behaviour Questionnaire	ICQ	50
Micalizzi et al.	574	2019	United States	51	10	4.1	18	CHAOS Scale	NIH Toolbox Early Childhood Cognitive Battery: Flanker Inhibitory Control and Attention Test and Dimensional Change Card Sort	DA	50
Peviani	167	2019	United States	47	21	17.0	35	CHAOS Scale	Delay Discounting Task	DA	100
Rea-Sandin	416	2018	United States	50	41	8.4	10	CHAOS Scale	DA: NIH Toolbox Early Childhood Cognitive Battery: Flanker Inhibitory Control and Attention Test and Digit Span Backward; ICQ: Temperament in	DA and ICQ	40

Table 1.

(continued)

Study Authors	N (analytic sample)	Year	Location of Study	Sex Composition (% female)	Racial/Ethnic Composition of Sample	Child Age (years)	Parental Education	HC Measure	EF Measure	Measurement Approach of EF	Hot (vs. Cool) EF
									Middle Childhood Questionnaire		
Schmitt et al.	359	2015	United States	49	51	4.5	NR	Residential mobility: "How many moves has your family experienced in the past 5 years?"	Day-Night Stroop Task	DA	100
Sturge-Apple et al. Study 1	194	2016	United States	56	54	4.1	23	Family Instability Questionnaire	Peg Tapping task and Reward Dominance task	DA	67
Sturge-Apple et al. Study 2	201	2016	United States	44	77	4.0	30	Family Instability Questionnaire	Mischel's Delay of Gratification task	DA	100
Taylor et al.	200	2005	United States	52	100	14.7	NR	Family Routines Inventory	School Engagement Attention Scale	ICQ	0
Valiente et al.	188	2007	United States	54	75	9.6	50	CHAOS Scale	Early Adolescent Temperament Questionnaire	ICQ	33

Table 1.

(continued)

Study Authors	N (analytic sample)	Year	Location of Study	Sex Composition (% female)	Racial/Ethnic Composition of Sample	Child Age (years)	Parental Education	HC Measure	EF Measure	Measurement Approach of EF	Hot (vs. Cool) EF
Vincent	309	2012	United States	NR	8	11.0	12	CHAOS Scale	Strengths and Weaknesses of ADHD symptoms and Normal Behavior subscales: Inattention, Hyperactive/	ICQ	50
Vrijhof et al.	418	2018	Netherlands	51	NR	3.9	NR	CHAOS Scale	Child Behaviour Questionnaire	ICQ	50
Zhao	154	2013	United States	49	100	8.0	0.1	Child Routines Questionnaire and Family Rituals Questionnaire	Early Adolescent Temperament Questionnaire (Parent Report)	ICQ	33

Note. HC = household chaos; EF = executive function; NR = not reported; CHAOS = Confusion, Hubbub, and Order Scale; DA = direct assessment; ICQ = informant-completed questionnaire. Racial/ethnic composition of sample = percentage of minorities; Parental Education = percentage parents with less than or equal to high school diploma/GED; Hot versus Cool EF = percentage of Hot EF. *Household disorganization indices: household density, visit preparedness, household cleanliness, neighborhood noise, and

TV hours per day; household instability indices: number of times the child moved to another residence, changes in the primary and/or secondary caregiver, different people in the household, and household members moved into or out of the household over this period.

Association between Household Chaos and Child Executive Functions: Overall Analysis

Figure 2 shows sample effect sizes. Correlations are consistently positive, ranging from 0.03 to 0.57. The weighted, mean association corresponds to r = .22, 95% CI [.17, .26]. Analyses revealed significant heterogeneity among effects, $Q(26) = 144.67$, $p < 0.001$. As per the I^2 index, 82.03% of this variance is due to true between-sample differences. Only measurement approach of executive functions significantly moderated the association between household chaos and child executive functions. The association was significantly stronger ($Q(1) = 7.53$, $p < 0.01$) when assessed with informant-completed questionnaires, r = .27, 95% CI [.21, .34], k = 13, than direct assessment, r = .16, 95% CI [.10, .21], k = 14.

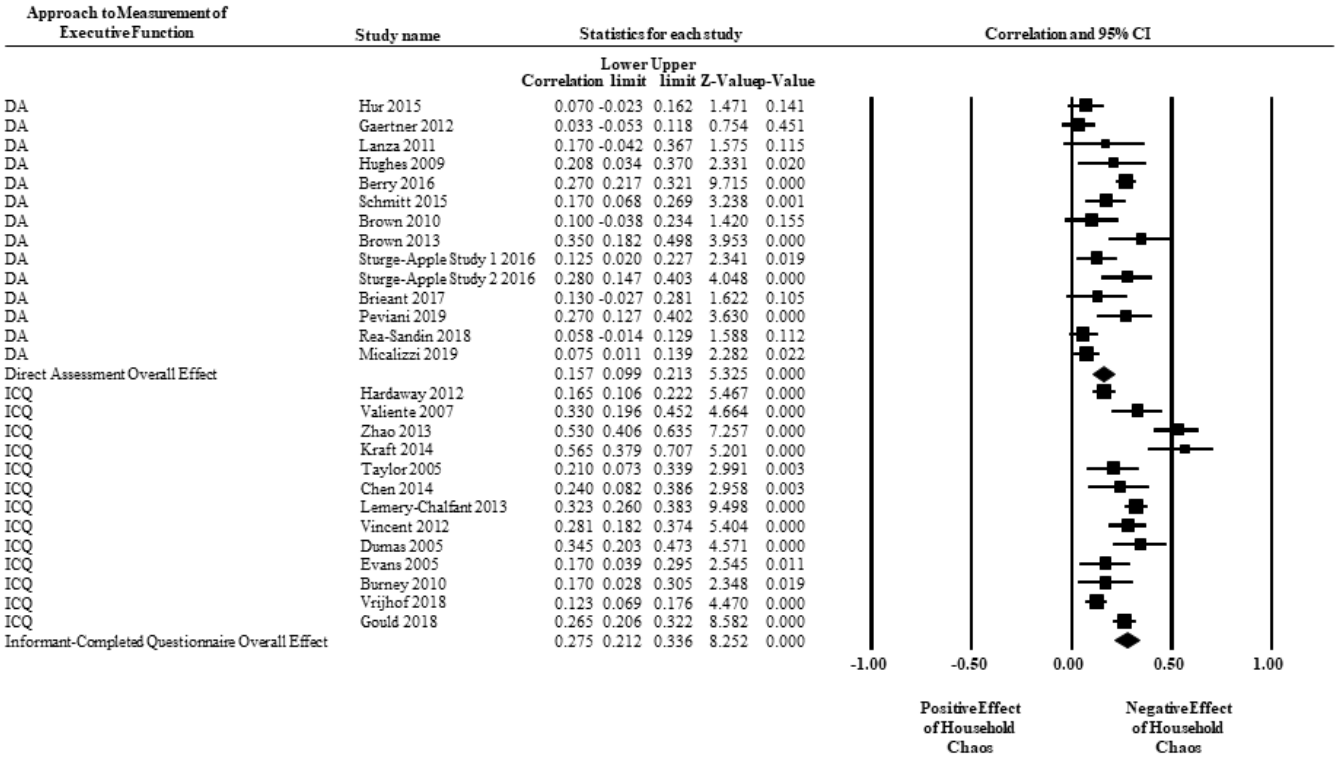

Figure 2. Forest plot with effect size estimates and confidence intervals of all studies included in meta-analysis based on measurement approach of executive functions.

Sensitivity Analysis

As mentioned previously, for three samples there were insufficient data available to calculate effect sizes. Therefore, an effect of 0.0 was imputed in these cases and the full sample of 30 effect sizes was analysed to estimate the impact of their inclusion. The sensitivity analysis yielded a weighted mean effect size of r = .19, 95% CI [.15, .24], only trivially discrepant from the mean effect size derived when these 0.0 effect sizes were excluded (r = .22). Heterogeneity also increased ($Q(29) = 195.25$, $p < 0.001$). Taken together, these findings indicate that the overall effect size estimate (based on k = 27) is robust in both magnitude and significance. Furthermore, the imputed r = 0.0 estimates fall outside the range of reported estimates and greatly increase heterogeneity, suggesting that the estimates are unrealistically conservative.

Analyses by Measurement Approach of Child Executive Functions

As highlighted in the introduction, there is limited shared variance between informant-completed questionnaires and direct assessment measures as reflected in their low intercorrelations, the likelihood that they tap different domains, and their differing underlying neural pathways. In addition, since the measurement approach of executive functions emerged as the single, significant moderator in the overall analysis, effect sizes were separated according to measurement approach and analyzed independently. For informant-completed questionnaires, four studies (k = 17) previously removed from the initial overall analysis were re-inserted. This had minimal impact on effect size, which diminished by .02 to yield a weighted mean strength of r = .25, 95% CI [.19, .30]. Effects were significantly heterogeneous, $Q(16) = 83.84$, $p < 0.001$, although examination of moderators (household chaos dimension, percentage of 'hot' executive function tasks, sex composition, mean child age, race/ethnicity, parental education, temporal distance) did not yield significance.

For direct assessment, effects were, again, significantly heterogeneous, $Q(13) = 54.62$, $p < 0.001$. A similar set of moderation analyses was performed in which three moderators emerged as significant. Chaos dimension significantly moderated effect size [$Q(2) = 14.24$, $p < 0.001$]: instability was associated with a significantly larger effect size (r = .21, 95% CI [.14, .28], k = 5) than disorganization (r = .09, 95% CI [.05, .14], k = 8). In addition, the strength of association between household chaos and child executive function increased with the increase in percentage of minorities in the sample (b = 0.002, SE = 0.001, k = 14, 95% CI [.0001, .003], R^2 = .48) (Figure 3) as well as with the percentage of parents with, or less than a high school diploma or GED (b = 0.003, SE = 0.001, k = 11, 95% CI [0, .005], R^2 = .44) (Figure 4).

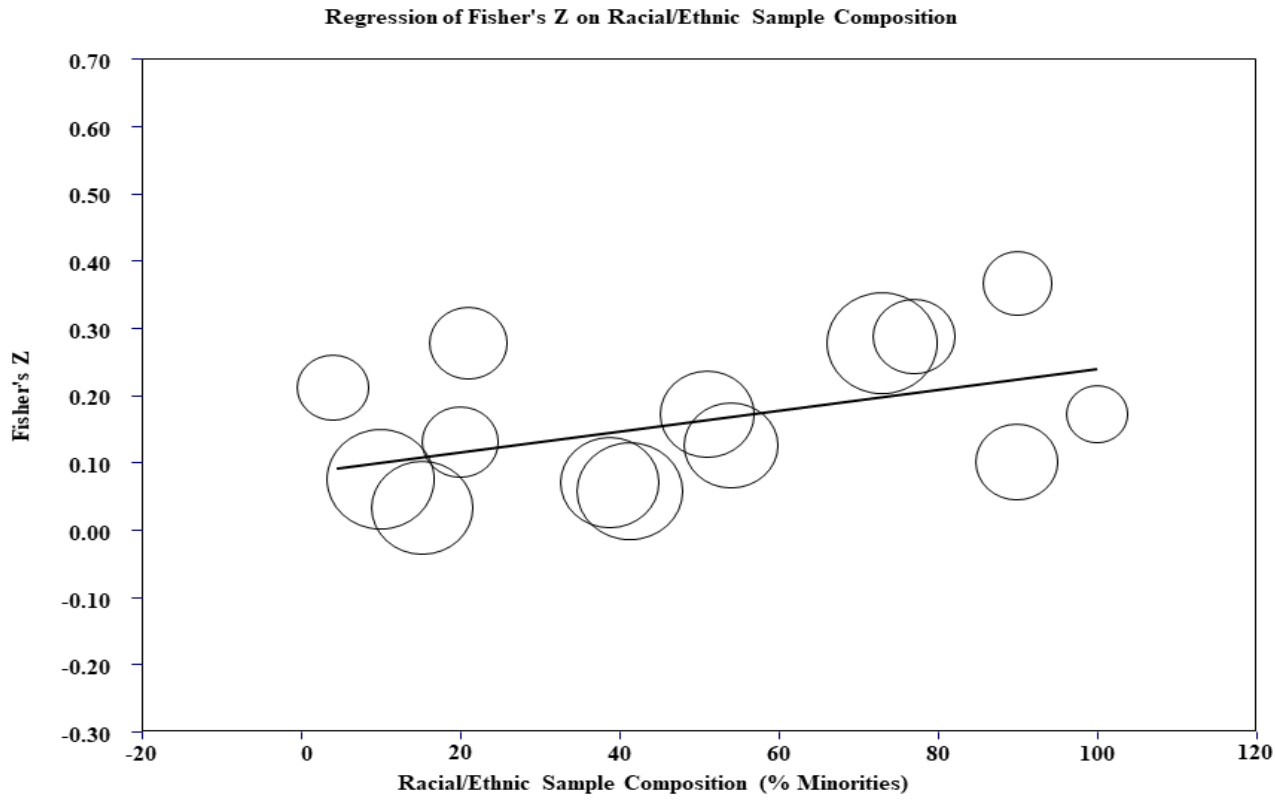

Figure 3. Scatterplot of the relationship between the racial/ethnic composition of the sample and the effect size between household chaos and child executive function in direct assessment meta-analysis.

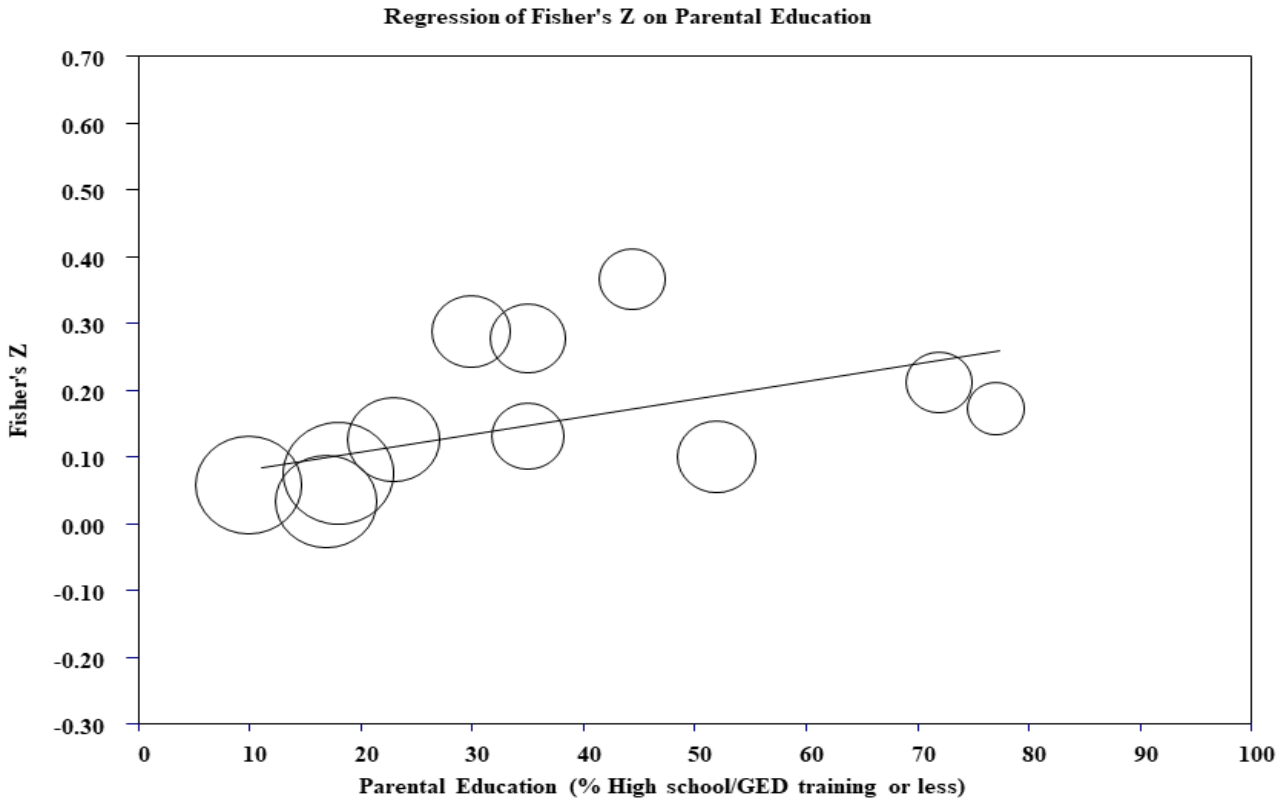

Figure 4. Scatterplot of the relationship between parental education and the effect size between household chaos and child executive function in direct assessment meta-analysis.

Sensitivity analyses

Sensitivity analyses were conducted for both informant-completed questionnaires (k = 19) and direct assessment (k = 17) studies, which included two and three additional samples, respectively, for which effect sizes were imputed as 0.0. For questionnaires, this analysis yielded a weighted mean effect size of r = .23, 95% CI [.17, .28] and heterogeneity increased, $Q(18)$ = 125.62. The direct assessment analysis yielded a weighted mean effect size of r = .13, 95% CI [.07, .18] and again, heterogeneity increased, $Q(16)$ = 81.21. These statistics indicate that the missing data likely have little effect on the estimates of effect size (a .02 and .03 difference for questionnaires and direct assessment, respectively) and significance.

Potential publication bias

The Duval and Tweedie procedure did not trim any studies for either the overall or information-completed questionnaire analyses; observed and imputed effect sizes were identical. Consequently, there is no reason to suspect publication bias in these analyses. For the direct assessment analysis, the Duval and Tweedie procedure trimmed two studies (Figure 5). However, the adjusted effect size (r = .14) remained significant and comparable to the observed effect size (r = .16).

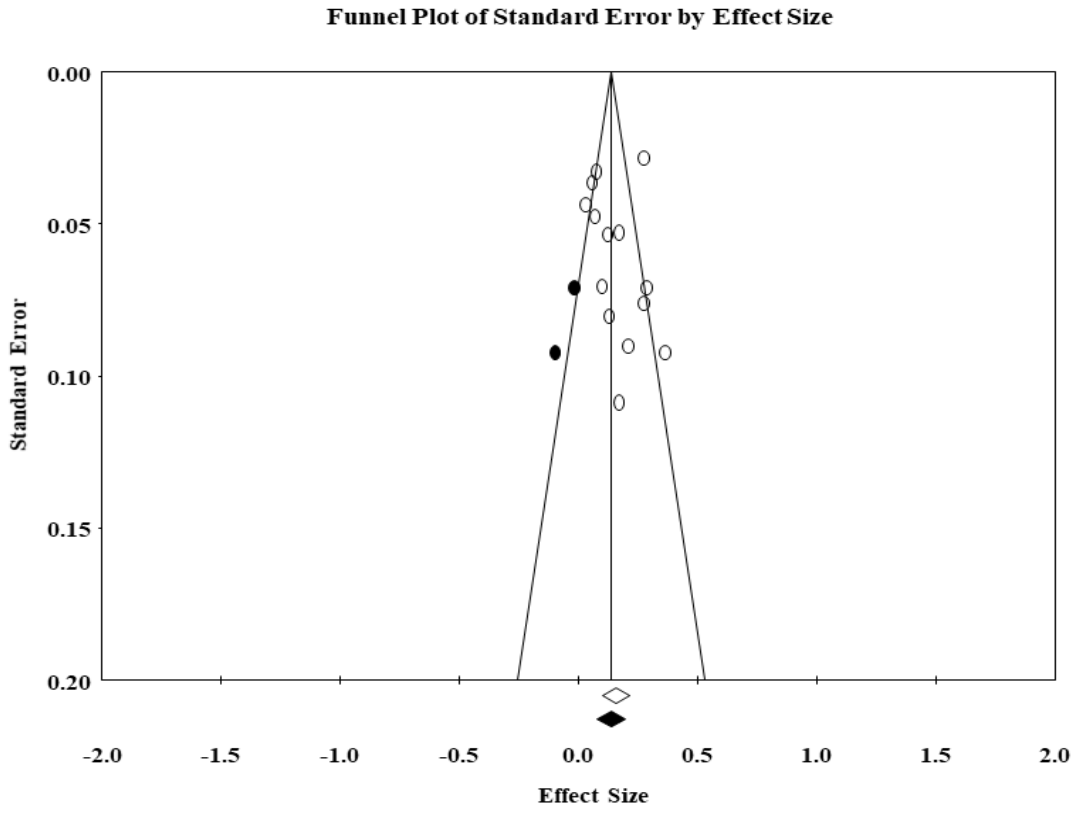

Figure 5. Funnel plot of the standard error by effect size for all studies included in the direct assessment meta-analysis.

Discussion

A meta-analytic review of household chaos and executive function is important given the increasing prevalence of chaos in North American homes (Bronfenbrenner et al., 1996; Lichter & Wethington, 2010) and the vulnerability of executive function development to such environmental factors. As such, this meta-analysis provides insight into critical foci for future research. Across the 27 independent samples examined in the overall analysis of the current study, we found significant evidence that household chaos is negatively associated with child executive functioning (defined in its broadest terms, including both informant-completed questionnaires and direct assessments). These findings are comparable to previous meta-analyses assessing other predictors of executive functions, including SES (Lawson et al., 2017), and acute stress (Shields, Bonner, & Moons, 2015; Shields, Sazma, & Yonelinas, 2016). In the moderator analysis, only measurement approach of executive functions was a significant moderator with a stronger association between household chaos and child executive functions found in studies that used questionnaires as compared to direct assessments. Questionnaire and direct assessment effects were heterogeneous, although no moderators were identified that explained this heterogeneity in the context of questionnaires. Respecting direct assessment, effect size depended on chaos dimension (instability versus disorganization), and proportion of minority families and parents with low educational attainment in the sample. Further details regarding the significant moderators are discussed below.

Measurement Approach of Executive Functions

As discussed, separate analyses conducted for informant-completed questionnaires and direct assessments were needed. The significant heterogeneity of the overall analysis due to moderation by measurement approach of executive function, and the findings that three

additional moderators emerged when the questionnaires and direct assessments were assessed separately are consistent with this decision. This suggests that the overall analysis may mask identification of potential moderators via error variance – another possible indication of the combination of measures assessing different constructs.

Informant-completed questionnaires may provide an ecologically valid assessment of child executive functioning in real-world settings (Toplak et al., 2013). However, they provide global ratings that may be confounded by other abilities (e.g. emotion regulation, motivation), thus limiting their discriminant validity. Further, questionnaires are susceptible to recall inaccuracies (Joyner, Silver, & Stavinoha, 2009; Wachs, 2013), and bias (Silver, 2014). Finally, shared method variance may also pose a problem because, of the 14 report-based studies in the overall analysis, 10 involved a single, parental informant for both household chaos and child executive functions. Of those with different informants, only one study (G. Evans et al., 2005) included an informant from a different setting (i.e. teacher), one included an adolescent informant (Taylor & Lopez, 2005) and the remaining 2 included combined scores of parents (Vrijhof, van der Voort, van IJzendoorn, & Euser, 2018) or parent and child (Valiente, Lemery-Chalfant, & Reiser, 2007). As such, the higher effect size generated by the questionnaires may be due to artifact and having another informant, in addition to the primary caregiver, would be useful to mitigate effects of shared variance (Duku & Vaillancourt, 2014).

Direct assessments may provide a more structured, refined setting to detect specific executive function skills due to their focus on how one processes information (e.g. response time, accuracy; Toplak et al., 2013). However, its estimation may be over (Franzen & Wilhelm, 1996) or underestimated (Cripe, 1996; Sbordone, 1996) given its rigid approach. Moreover, its highly structured approach limits a child's ability to use compensatory skills that they may

otherwise use in real world contexts (Chaytor, Schmitter-Edgecombe, & Burr, 2006). With that said, in the current review, direct assessments show greater sensitivity to moderating factors, despite their smaller effect size. This underscores the possible important role of direct assessment measures to a nuanced understanding of the relation between chaos and executive function. Ultimately, more research is needed, and it may be that a multidimensional approach incorporating both questionnaire and direct assessment methodologies is necessary to the comprehensive study of chaos and executive function.

Moderation within Direct Assessments

Household chaos dimension

The instability dimension of household chaos was more strongly associated with child executive function than the disorganization dimension. Although not considered to be as prevalent as disorganization, even some exposure to instability during early and middle childhood (e.g. changes in residences, housing structure and/or caregiver structure) can have significant effects on behavioural functioning (Fomby & Cherlin, 2007; Tiesler et al., 2013; Ziol-Guest & Mckenna, 2014). For example, children who moved at least once between preschool and fifth grade, showed deficits in executive functioning (via direct assessment; Roy, Mccoy, & Raver, 2014). Similar trends are seen with changes to maternal partners in dating or co-residential relationships where more frequent changes were linked to deficits in attentional skills (Cooper, Osborne, Beck, & McLanahan, 2011). Overall, while instability seems to have a potent effect on child executive functions, given the small dataset, it would be important to further investigate within a larger scale, longitudinal study. There is a need to better represent the instability dimension of household chaos in its study, given an apparent gap in examining this

dimension of chaos with respect to its differential and joint (with disorganization) effects on child executive functioning.

Race/Ethnicity Composition of Sample

Racial/ethnic composition of the sample also emerged as a significant moderator such that larger effect sizes between household chaos and child executive functions were found for samples with higher proportions of minorities. No research, to our knowledge, has directly focused on the impact of children's race/ethnicity and household chaos on child executive functions. An examination of studies with related child outcomes indicate that race/ethnicity findings are mixed. For example, race accounted for small but significant variance in household disorganization along with other SES indicators (e.g. maternal education), such that higher household disorganization was experienced by African American children (Garrett-Peters et al., 2016). However, race was not significantly associated with household instability or child academic achievement. Conversely, higher familial transitions (a measure of instability) were associated with higher externalizing and delinquent behaviours in Caucasian children only, with no difference observed across races for academic achievement (Fomby & Cherlin, 2007). These equivocal findings regarding the role of race/ethnicity also extend to SES and executive function research (Dilworth-Bart, Khurshid, & Vandell, 2007; Lawson et al., 2017; Raver et al., 2013). Further research is needed to disentangle the role (if any) that race/ethnicity plays in the association between household chaos and child executive function.

Parental Education

The effect of household chaos on child executive functioning was greater in samples with parents that had less educational training. Significant associations have been demonstrated between maternal education and both household chaos (Garrett-Peters et al., 2016; Whitesell,

Teti, Crosby, & Kim, 2015) and child executive functioning (Vernon-Feagans et al., 2016), such that less educational training was associated with higher levels of household chaos and poor executive functioning. Higher levels of chaos in homes found for parents with less education and lower intelligence levels may impact their ability to provide environments with high-quality parent-child interactions and literacy enrichment (Deater-Deckard et al., 2009) which can impact child executive functioning. This intersection between household chaos and parental education highlights the importance of equipping parents with the knowledge and tools needed to create more predictable and organized environments for their children.

Potential Mechanisms of Effect

A number of potential mechanisms could account for the association between household chaos and child executive function. First, one may argue that exposure to chaos can elicit stress in children, which in turn may impact their executive functioning. Exposure to chronic stress leads to dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis which can result in potentially lasting structural and functional changes in the prefrontal cortex and associated regions (e.g. hippocampus, amygdala) (Arnsten, 2009; Teicher et al., 2003) – all areas of the brain relevant to executive function, memory and emotion regulation. Chronic stress, then, is a likely mechanism through which household chaos exerts its effects on child executive functioning and its underlying neurobiology and should be explored in future research.

A second possible mechanism is a 'system of chaos' which may be generated via disruptions to parent-child interactions. The interaction between parent and child is reliant, in part, on the executive functioning of each party. If both parent and child have deficits in their executive functioning subsequent dyadic interactions may then be more disruptive, generating an overall 'system of chaos'. Within this 'system of chaos' parenting behaviours can also be

disrupted. For example, higher chaos within the home has been linked to ineffective disciplinary practices (Dumas et al., 2005), less warmth (Deater-Deckard et al., 2009), lower maternal emotional availability (Whitesell et al., 2015), and poor caregiver attention regulation (Mokrova, Brien, Calkins, & Keane, 2010). The quality of parent-child interactions and its effect on child executive functioning is extensively documented (Bernier, Carlson, Deschênes, & Matte-Gagné, 2012; Hughes & Devine, 2017). However, only one study to date has formally showed that household disorganization experienced over the span of three years has a negative, indirect effect on child behavioural regulation (i.e. working memory, attention, inhibitory control) via parenting behaviours (i.e. acceptance and responsivity) and early executive function skills (i.e. at age three). Taken together, it is possible that a) parental executive function deficits may impact the dyadic interaction with the child creating a 'system of chaos'; and b) the reciprocal relationship between chaos and parental behaviours may further exacerbate negative effects on child executive functioning.

Limitations

This meta-analysis represents a comprehensive review of all identified studies of household chaos published to date. Importantly, it showed a substantial and significant effect size difference when informant-completed questionnaires and direct assessments were compared. We considered maintaining a combined (informant-completed questionnaire + direct assessment) approach and simply evaluating all potential moderators in terms of their interaction with methodological approach. However, it appears that the two approaches differ in their focus sufficiently to preclude their common analysis. Furthermore, as with all meta-analyses, sample size diminishes in the context of moderation analysis because relevant data are often missing. For example, we were unable to assess the impact of child verbal ability, parental age and certain

SES indices (e.g. income-to-needs ratio) due to missing data and/or restricted data ranges. This signals the need for future researchers to include relevant data for the purpose of analyzing important moderators. Additionally, few studies (k = 3) measured household chaos across different time points which eliminates opportunity to assess the stability of chaos over time and its subsequent effects on child developmental outcomes. Finally, in three cases, data linking chaos and executive functions were missing. We excluded these studies from relevant analyses (which, in theory, could inflate estimated effect size based on publication bias), however, sensitivity analyses wherein effect sizes were imputed as zero revealed only trivial impact.

Conclusion

Household chaos poses a significant risk to the development of executive functions in children. The current meta-analysis highlights the importance of multi-method approaches in measuring executive function in children in order to ensure rigorous and accurate assessment. These findings can inform the development of preventative strategies for children and their families aimed at the reduction of disorganization (e.g. minimizing clutter and ambient noise) and providing greater stability (e.g. promotion of routines) within the home environment. There are evidence-based interventions for executive functioning, however, a more multi-faceted approach may be required, targeting household chaos as a risk factor and child executive function as an outcome in order to tailor to interventions to the specific needs of families.

Chapter 3: Study 2

General Purpose

Various factors contribute to the individual differences in child executive functioning which has long term consequences for their future socioeconomic status, employment, physical and mental health (Moffitt et al., 2011). Household chaos is a viable contextual risk factor that disrupts the proximal processes that are central to shaping child executive functioning. Studies have demonstrated its direct effect on executive functions (Dumas et al., 2005; Hughes & Ensor, 2009). However, less is known about the underlying mechanism through which household chaos influences child executive functioning. Parenting has emerged as a plausible factor mediating the effects of household chaos on child executive functioning. Studies have demonstrated that chaotic homes can impact the sensitivity, responsiveness and involvement of parents with their children (Wachs, 2005). There is also a wealth of research demonstrating the role parenting plays in shaping the development of executive functioning (Bernier et al., 2012; Hardaway, Wilson, Shaw, & Dishion, 2012; Sulik et al., 2015). The objective of this second study is the examine both the direct effects of household chaos on child executive functioning and indirect effects via parenting as measured by cognitive sensitivity and emotional availability. Further, given gaps in the literature regarding the possible differential effects of the household chaos dimensions on child executive functioning via this indirect mechanism, the effects of both disorganization and instability will be explored. Finally, to date, no study to the best of my knowledge, has explicitly examined sex differences in the context of household chaos, parenting and child executive functioning – as such this will also be explored.

Title and Authorship

Title: Impact of household chaos and parenting on child executive function: A novel, multi-method approach

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Conflicts of Interest: None

Abstract

Executive functions are higher order cognitive processes (e.g. inhibition, working memory, cognitive flexibility) that are important to engaging in goal directed behaviours. Their development is affected by the dynamics within the home environment; with contextual risks such as chaotic households and parenting challenges having adverse effects. Furthermore, household chaos has also been found to negatively influence parenting. Few studies, however, have examined the role of parenting in the association between household chaos and child executive functions. The objectives of the present study were three-fold: 1) to examine the potential direct and indirect effects (via parenting) of household chaos on executive functioning; 2) explore potential differential effects of instability and disorganization dimensions of household chaos on child executive function via the indirect effects model; and 3) explore possible sex differences in the effect of household chaos on child executive functioning. Data were derived from a sample of 132 school-aged children (49% female) and their mothers in the Hamilton, ON region. Household chaos was measured in multiple, novel ways: 1) the Confusion, Hubbub, and Order Scale (CHAOS); 2) self-report of number of residential moves and caregiver changes; and 3) a maternal guided tour of the home, scored for household chaos-related variables via Linguistic Inquiry and Word Count (LIWC) software. Mother-child videotaped interactions were coded for cognitive sensitivity and emotional availability. Mothers and children completed behavioural assessments measuring executive functions including inhibition, working memory and cognitive flexibility. Structural equation modelling of direct and indirect effects of household chaos on a latent variable of child executive functioning was examined using version 8.3 of Mplus software. Covariates included income, child gender, and maternal depression and executive functions. The results indicated that household chaos had both

a direct effect on child executive functioning (β = -.31, 95% [-.59, -.04]) and indirect effect through parenting (β = -.05, 95% [-.13, -.01]). Of the covariates included, only income was significantly associated with child executive functioning (β = .32, 95% [.05, .59]. Further household instability, but not household disorganization, was demonstrated to have a direct (β = -.28, 95% CI [-.54, -.01]) and indirect effect (via parenting) (β = -.05, 95% CI [-.13, -.004]) on child executive functioning. Finally, significant indirect effects of household chaos on child executive functioning was only found in male children. These findings reveal parenting as an important mechanism through which household chaos exerts its effects on executive functioning of school-aged children. This can potentially inform the development of preventative strategies for children and their families aimed at improving parenting and providing greater stability within homes.

Introduction

The development of executive functions in early childhood plays an important role in shaping the overall functioning of the child. Executive functions (e.g. inhibition, cognitive flexibility, working memory) describe neurocognitive processes that modulate one's thoughts, emotions and actions in goal directed behaviours (Diamond, 2013; Miyake & Friedman, 2012). The prefrontal cortex (PFC) and its connections with other striatal regions serves as the underlying neurobiological substrate of executive functions (Gogtay et al., 2004; Shaw et al., 2008). Postnatal development of the PFC is prolonged as evidenced by the timing of gray matter loss, pruning and myelination (Diamond, 2002, 2006). The trajectory of this maturation is aligned with rapid developmental periods of executive functions across childhood and adolescence through to early adulthood (Anderson, 2002; Diamond, 2006; Marsh, Gerber, & Peterson, 2008; Shaw et al., 2008). This prolonged postnatal development (Gogtay et al., 2004) in the PFC, leaves the PFC and therefore, executive functions, vulnerable to the effects of early adversity (Pechtel & Pizzagalli, 2011; Teicher et al., 2003). As such, consideration of the quality of the home environment and parent-child interactions are important as they may significantly shape a child's developmental trajectories.

Numerous factors contribute to individual differences in child executive functioning, including parenting, socioeconomic status (SES) and early life stress (Bernier, Carlson, & Whipple, 2010; Hackman, Gallop, Evans, & Farah, 2015; Lawson, Hook, & Farah, 2017; Pechtel & Pizzagalli, 2011). These individual differences have implications for numerous developmental outcomes including communication and social skills (Clark et al., 2002), verbal and nonverbal reasoning (van der Sluis, de Jong, & van der Leij, 2007), behaviour problems (Volckaert & Noël, 2018), school readiness (Blair & Raver, 2015), and academic achievement (Blair & Razza,

2007). Furthermore, poor executive functioning in childhood can be predictive of problems with physical health, greater likelihood of engagement in criminal activity and drug dependency, and lower SES in adulthood (Moffitt et al., 2011). Identifying potential factors within the child's environment that may contribute to individual differences in executive function is important for a wide range of outcomes. Household chaos is a viable contextual factor that negatively impacts child executive functioning (Hughes & Ensor, 2009). However, despite these established associations, the mechanisms through which household chaos exerts its effects on child executive functions have yet to be fully elucidated. The purpose of the current study is to explore the role of parenting in the association between household chaos and child executive functions. Specifically, this study examined whether household chaos influences child executive functions through parenting in a sample of school-aged children.

Household Chaos as Predictor of Child Executive Functions

Household chaos describes an environment of uncontrolled activity, ambient noise, lack of structure and unpredictable routines (Bronfenbrenner & Evans, 2000). It is characterized by two dimensions: disorganization and instability. Disorganization includes: clutter, ambient noise, crowding and lack of structure; and instability refers to frequent changes in residence, residents (e.g. primary or secondary caregivers) and routines (Brooks-Gunn et al., 2010; Wachs & Evans, 2010). Although linked to poverty, household chaos has been shown to impact parenting and child outcomes across SES gradients (Corapci & Wachs, 2002; Dumas et al., 2005; Hygge et al., 2002) suggesting that it is not simply a proxy for poverty (Wachs & Evans, 2010). Studies have demonstrated the adverse impact of household chaos on child and adolescent outcomes including deficits in socioemotional development (Evans, Gonnella, Marcynyszyn, Gentile, & Salpekar, 2005), poor language and early literacy development (Johnson & Martin, 2008; Vernon-Feagans

et al., 2012), lower intelligence levels (Deater-Deckard et al., 2009), deficits in academic achievement (Garrett-Peters et al., 2016), conduct problems and callous-unemotional behaviours (Mills-Koonce, Willoughby, Garrett-Peters, Wagner, & Vernon-Feagans, 2016), and poor physiological functioning (Brown, Anderson, Garnett, & Hill, 2019). Additionally, direct associations have been made between higher household chaos and poor performance in tasks related to executive functions (e.g. inhibitory control, cognitive flexibility and working memory) (Hughes & Ensor, 2009). Similar trends are seen with attention (Brown, Weatherholt, & Burns, 2010) and effortful control (Chen et al., 2014; Peviani et al., 2019) which are theoretically linked to executive functions and typically assessed in children (Diamond, 2013; Zhou et al., 2012). Further, given the broad characterization of household chaos, several studies have examined the differential effects of household chaos dimensions (disorganization and instability) on child executive functioning.

Disorganization versus Instability and Child Executive Functions

Greater household disorganization experienced in the first three years of life has been modestly, but significantly associated with poor performance in tasks measuring inhibitory control, attention shifting and working memory at age four (Berry et al., 2016). Further, preschool children who were exposed to greater ambient noise (as measured by maternal reports of the frequency in which the television was playing in the home) experienced greater attention problems at kindergarten age (Martin et al., 2012), as well as challenges with inhibitory control and working memory (Blankson et al., 2015). Although likely not as prevalent as disorganization, even modest exposure to instability during early and middle childhood (e.g. changes in residences, housing structure and/or caregiver structure) can have significant effects on cognitive and behavioural functioning (Fomby & Cherlin, 2007; Tiesler et al., 2013; Ziol-

Guest & Mckenna, 2014). For example, children who experienced greater household instability demonstrated greater difficulties with effortful control from ages four to six years (Sturge-Apple, Davies, Cicchetti, Hentges, & Coe, 2017). Similarly, residential mobility was found to be negatively associated with inhibitory control in preschool children (Schmitt et al., 2015) and adolescents (Roy et al., 2014). Taken together, this suggests that both dimensions are important to consider when evaluating the effects of household chaos on child outcomes (Sameroff, 2010; Wachs & Evans, 2010).

The Role of Parenting

Mechanisms linking household chaos to child executive functioning via parenting have not been extensively studied, however given the importance of parenting on child executive function (Bernier et al., 2010) and some evidence that household chaos impacts parenting (Coldwell, Pike, & Dunn, 2006), it is a plausible candidate.

Parenting as Predictor of Child Executive Functions

Robust associations have been documented highlighting that the quality of parent-child interactions plays an important role in child executive functions. Early childhood, in particular, is an important time to establish the secure bond between parent and child as this can have a positive impact on the child's executive functioning at school-age (as compared to toddlers who had insecure attachments to their parents; Bernier et al., 2015). Additionally, early exposure to parental qualities such as sensitive and responsive caregiving have been positively associated with inhibitory control, working memory and cognitive flexibility in four and five year old children (Sulik et al., 2015). Similar findings have been demonstrated with positive associations between parental scaffolding and the executive functioning of a sample of preschool children (Hammond, Mu, Carpendale, Bibok, & Liebermann-Finestone, 2012). Further, high maternal

autonomy support experienced by children from birth to three years of age has been shown to predict better performance on tasks of inhibition, effortful control and sustained attention prior to kindergarten, with these skills having a lasting, positive effect on academic achievement in elementary and high school (Bindman, Pomerantz, & Roisman, 2015). Conversely, parents who exhibit negative affect, criticism and controlling behaviours can adversely impact child executive functioning (Hughes & Devine, 2017), with similar inverse associations demonstrated between inconsistent discipline and inhibitory control and attention skills (Sosic-Vasic, Kröner, Schneider, Vasic, & Spitzer, 2017).

Household Chaos and Parenting

Although not as extensively examined, many studies have presented evidence of negative associations between household chaos and parenting (Coldwell et al., 2006; Corapci & Wachs, 2002; Vernon-Feagans et al., 2016). For example, mothers who report high levels of chaos in their homes have also reported that they tend to employ ineffective disciplinary practices (Dumas et al., 2005). Further, chaotic homes have been found to be associated with less responsiveness, sensitivity and involvement of parents with their children (Wachs, 2005) and lower parenting self efficacy beliefs (Corapci & Wachs, 2002). Greater chaos and poor housing conditions (i.e. dirt/clutter and health/safety) were also associated with less warmth and more negativity from parents as well as reports of experiencing more stressful events (Deater-Deckard et al., 2009). Similarly, with infants, the quality of co-parenting, as reported by mothers and fathers, was significantly lower with the experience of high levels of household chaos as compared to parents who experience low levels of household chaos (Whitesell et al., 2015). Further, higher household chaos was also associated with significantly lower maternal emotional availability at bedtime with their infants. Household chaos, then, can hinder a parent's ability to

effectively attend to and interact with their child which can threaten the child's development of executive functions. Thus, parenting is a likely factor through which household chaos can impact child executive functioning.

Indirect Effects of Household Chaos on Child Executive Function via Parenting

Previous studies have demonstrated the indirect effects of household chaos on externalizing and internalizing behaviours (Deater-Deckard et al., 2019), receptive and expressive language (Vernon-Feagans et al., 2012), cognitive ability (Evans et al., 2010), children's representations of family dysfunction (Zvara et al., 2014) and conduct problems and callous-unemotional behaviours (Mills-Koonce et al., 2016) via parenting. Few studies, however, have examined parenting as a mediator between household chaos and child executive functions. For example, in a sample of school-aged children, parental positive reactions to child emotions significantly mediated the association between household chaos and child effortful control (Valiente et al., 2007). Additionally, household disorganization experienced during the first three years of life exerted a negative, indirect effect on the behavioural regulation (i.e. working memory, attention, inhibitory control) of kindergarten-aged children via parenting (i.e. acceptance and responsivity) and early executive function skills (i.e. at age three years; Vernon-Feagans et al., 2016). The current study posits that parental responsiveness may be compromised under conditions of high household chaos which can adversely affect child executive functions.

While evidence regarding the role of parenting in the association between household chaos and child executive function is emerging, a number of gaps remain. First, many studies to date have not examined the potential differential effects of instability and disorganization. Second, no study has examined the potential moderating effect of child sex on paths linking household chaos and child executive function. This is relevant because the findings regarding the

possible sex-based differences in how contextual factors impact child executive functioning are mixed (Grissom & Reyes, 2018) requiring further investigation. Third, household chaos is typically examined using self-report measures. Here, however, we include a novel index of household chaos in addition to self-reports: narrated home video tours from which chaos-related content in maternal speech is extracted.

Current Study

The aim of the current study was to: 1) examine direct effects of household chaos on child executive function and indirect effects via parenting; 2) explore potential differential effects of instability and disorganization dimensions of household chaos on child executive function within an indirect effects model; and 3) identify possible sex differences in the effect of household chaos on child executive functioning directly and indirectly via parenting.

Methods

Sample

A sample of 137 children and their mothers participated in the current study from June 2016 to August 2018. The majority of participants (n = 91) were a part of a larger longitudinal study examining the effects of maternal history of maltreatment on parenting practices and child cognitive and socioemotional outcomes. Study inclusion included: 1) mothers were 18 years or older at time of birth; 2) mothers gave birth to full term, healthy infant; 3) mothers were able to access their infants at the time of the home visits; and 4) mothers were able to read, write and speak English language. Exclusion criteria included any barriers to completion of research measures (e.g. severe disability, language barriers). A new sub-sample of participants (n =46) was recruited from a database of families as a part of the Department of Psychology, Neurosciences and Behaviour at McMaster University. Prior consent had been provided by

families to be contacted for research purposes. Eligibility of participants in the sub-sample matched that of the participants recruited from the larger longitudinal study. At the point of recruitment for the new sub-sample, eligible participants were mothers with children between the ages of 4 years 11 months and 5 years 8 months old. Families were contacted via telephone following a pre-approved script. Those who provided verbal, informed consent over the telephone were scheduled for a home visit during which written, informed consent was obtained for all study participants. The study protocol was approved by the McMaster Research Ethics Board and the St. Joseph's Healthcare Hamilton Research Ethics Board.

In the final sample, consisting of 128 participants (43 participants were from the sub-sample); a total of 9 mother-child dyads were excluded due to the following reasons: children with severe developmental delay (N = 2) and insufficient child measures completed (N = 7). The mean age of the children was 61.9 (SD = 2.0) months, with 49% females. Race composition consisted of 83.6% White, 2.3% Black, 2.3% Asian, and 11.8% Other (included those who reported more than one race). The majority of the mothers were married or in common-law relationships (87.9%). Approximately 36.4% of mothers had university level training, 27.3% had a college education and 26.5% had post-graduate training. The remaining 9.8% had a high school diploma or less. The median household income range was $105,000-133,499 CAD.

Procedure

Home visits were conducted with mother-child dyads by two female research assistants. Visits were approximately 2 hours in duration. Mothers completed a questionnaire package addressing their emotional health and current stressors; their child's health and development; and their household environment. The visit also included a video tour of the home conducted by mothers, videotaped mother-child interactions, and behavioural assessments of executive

function completed by the mother and child independently. Participants were compensated for their time with $20 CAD and a toy for the child.

Measures

Household Chaos

CHAOS Scale. Mothers reported levels of household chaos with the Confusion, Hubbub, and Order Scale (CHAOS; Matheny, Wachs, Ludwig, & Phillips, 1995). The scale consists of fifteen items on a four-point scale (*1 = very much like your own home, 4 = not at all like your own home*). Items included "We can usually find things when we need them" and "Our home is good place to relax." The total score from the scale reflects the extent of household chaos in the living environment, with a higher score indicating greater chaos in the home. The scale has demonstrated good test-retest reliability over a 12-month period (r = .74) and in the present sample, high reliability (Cronbach's α =.85).

Narrated Home Video Tours. Mothers conducted videotaped tours of their home based on a pre-established methodology (Saxbe & Repetti, 2010). Mothers were instructed to emphasize meaningful home spaces and possessions (e.g. describe space and possessions which are most important to your family) during the tour. The research assistant did not accompany the mother on this tour. Tours ranged from 1 minute, 4 seconds to 14 minutes, 51 seconds. Videos were transcribed verbatim by two independent researchers and 20% were checked by a third research assistant. Most of the videos were continuous, however, there were few cases where videos were stopped and then resumed shortly after. Only the mother's dialogue was transcribed. Where mothers engaged in extensive dialogue (i.e. beyond 2 lines of text) with other family members during the tour, the responses beyond the first reply were removed.

A Linguistic Inquiry and Word Count (LIWC) software was used to analyze transcripts of the home tours via generating word frequency counts for specified categories. In order to capture the construct of household chaos, a custom dictionary was created following the pre-established protocol of LIWC developers (Pennebaker, Chung, Ireland, Gonzales, & Booth, 2007). Briefly, to generate a list of words and phrases relevant to household chaos, multiple steps were taken. First, the CHAOS scale, extant household chaos literature and a sub-set of the transcripts were reviewed to extract chaos-related terms (see Table 2). Second, using these words, a codebook was systematically developed by two trainees (KA, AT). Third, all transcripts were entered into NVivo 12 Plus qualitative data analysis software (QSR International, 2018) and reviewed by the study's first author to categorize relevant words and phrases. The subsequent lists were reviewed and rated systematically by two independent trainees (KA, SK) to create the final custom dictionary. The dictionary and transcripts were entered into the LIWC software, from which final word frequencies for the household chaos categories were obtained.

Family inventory of life events and changes (FILE). The Family Inventory of Life Events and Changes (FILE) 9-item questionnaire assessing the family's experience of a variety of life changes (McCubbin, Patterson, & Wilson, 1983) was completed by mothers. Mothers indicated whether they had experienced each event in the past month, past year, lifetime, never or prefer not to answer. One item pertaining to changes in relationship status (e.g. divorce, separation, remarriage, new partner) within the past year was used due to its statistical and theoretical relevance to household chaos.

Residential Mobility. Mothers were asked the number of times their child had moved from one residence to another in the past 5 years as a part of a larger demographic questionnaire.

Parenting

Structured Etch-A-Sketch Task. Mother-child dyads were videotaped as they participated in a structured interaction task - the Etch-a-Sketch task (Stevenson-Hinde & Shouldice, 1995). Mothers and children were each assigned a knob and instructed that there were not allowed to touch or manipulate the other's knob. In the practice trial, they were given a picture which depicted two stacked rectangles (of differing widths) and were instructed to draw it using the etch-a-sketch. Once completed, a test trial was administered in which they were now instructed to draw a picture of a house provided to them. There was no set time for completion. Parenting was coded for cognitive sensitivity (Prime et al., 2015) and emotional availability (EAS; Biringen, 2008). Cognitive sensitivity includes indices for mind reading, communicative clarity, and mutuality building behaviours (Prime et al., 2015). Three independent coders established reliability (Cronbach's $\alpha > .80$) with an expert coder (developer of cognitive sensitivity scale) before coding the remaining videos independently. Coders used a 5-point Likert scale for each of the 11 items with responses ranging from 'Not at all true' (1) to 'Very true' (5). A mean of the 11 items was calculated and used as the final score with higher scores indicating higher cognitive sensitivity. A random selection of videos was chosen to double code and inter-coder reliability was good (Cronbach's $\alpha = .80$). For any discrepancies in codes, the scores of the expert coder was used as the final score. Emotional availability was measured using the 4th edition of the Emotional Availability Scales (EAS; Biringen, 2008). A primary coder (trained and EAS certified) scored the parent-child interaction videos using four parent scales – sensitivity, structuring, non-intrusiveness, and non-hostility – from 1 to 7. A subset of 20 videos was coded by a second trained and certified EAS coder reliability between coders was good (ICC

= .81). Sum scores of the four scales for each dyad were made where higher scores indicate higher emotional availability.

Executive Functioning

Measures from the National Institute of Health (NIH) toolbox: Cognition Battery (Weintraub et al., 2013; Zelazo et al., 2013) were used for mothers and children in assessing various executive functions. Tasks were completed on an iPad provided by the research assistants. Mothers and children completed the measures of inhibitory control and cognitive flexibility. Children also completed a measure of episodic memory. The NIH toolbox is a computerized battery of measures that can be administered to participants aged 3 to 85.

Maternal Executive Functioning. Mothers completed the Flanker Inhibitory Control and Attention Test (Flanker) and the Dimensional Change Card Sort (DCCS).

Inhibitory Control and Attention. The Flanker task assesses the mother's ability to attend to single visual stimulus and ignore distractor stimuli. The research assistant read the instructions on the screen to the mother to attend to the middle arrow (visual stimulus) and choose the button that matches the direction that it is pointing. Two types of trials were presented to the mother – in one trial, the middle arrow faced the same direction as the other arrows in the row (congruent) and in another trial, the middle arrow faced the opposite direction of the other arrows (incongruent). The mother was given up to three practice rounds with four trials within each (if needed). The test trials consisted of 20 items with arrow stimuli. Scoring was based on both accuracy and reaction time. If the accuracy levels were below 80%, the computed score was equivalent to the accuracy score. However, if at 80% or higher, the reaction time was combined with the accuracy score. The scores were adjusted for age based on a normative sample (Slotkin

et al., 2012). Higher scores indicate better inhibitory control and attention. Reliability and validity was excellent for this measure (Weintraub et al., 2013).

Cognitive Flexibility. Mothers completed the DCCS that consisted of two blocks: practice and mixed. In the practice block, mothers were instructed that they were going to sort stimuli by dimension (i.e. shape or colour). The mother was shown a visual stimulus (e.g. brown rabbit) and instructed to match the stimulus by shape to one of the two other stimuli (e.g. brown rabbit, white boat) presented below it. Mothers had to get at least 3 out of 4 correct to move on, otherwise, they were given up to three rounds of practice (each with four trials). In the second practice round, mothers had to match the presented visual stimulus (e.g. white boat) to one of the two other stimuli (e.g. white rabbit, brown boat) shown below it by colour. Mothers were provided a visual cue (i.e. star appearing in middle of screen) to direct their attention to the fixation point throughout the task. The Mixed block comprised the test trials where the stimuli were changed to trucks and balls that were yellow and blue. Mothers had to match the presented visual stimulus by shape or colour to one of two other visual stimuli presented below it. There were 30 test items and the dimensions alternated. The scoring for DCCS was the same as described for the Flanker test. Higher scores indicate better cognitive flexibility. Reliability and validity was excellent for this measure (Weintraub et al., 2013).

Child Executive Functioning. Children also completed the Flanker and DCCS tasks as well as the Picture Sequence Memory Test (PSMT). Additionally, children completed two additional tasks that were not a part of the NIH toolbox: Backward Digit Span and Simon Says.

Inhibitory Control and Attention. The child version of the Flanker task was similar to that of the adult; however, they were presented up to two test rounds with the first involving fish stimuli and the second involving the arrow stimuli. The research assistant read the instructions

on the screen to the child to direct their attention to the middle fish and choose the button that matches the direction that the middle fish is pointing. Visual and verbal cues were provided by the program to direct the child's attention to the fixation point at the middle of the screen. The child was given up to three practice rounds with four trials within each (if needed). The test trials consisted of 20 items with fish stimuli. A score of greater or equal to 90% on these test trials was required for the child to move onto the additional 20 test trials with arrows as the visual stimuli. Scoring was the same as described for the maternal Flanker task. Higher scores indicate better inhibitory control and attention. Developmental sensitivity, test–retest reliability, and convergent validity of this task are excellent for this age group (Weintraub et al., 2013; Zelazo et al., 2013).

Cognitive Flexibility. The child version of the DCCS consisted of four blocks: practice, pre-switch, post-switch and mixed. The practice block followed the same rules as in the adult version. Children were provided a visual cue (i.e. star appearing in middle of screen) to direct their attention to the fixation point throughout the task. The test trials consisted of the pre-switch, post-switch and mixed blocks where the stimuli were changed to trucks and balls that were yellow and blue. No feedback was provided by the research assistant for these rounds. In the Pre-switch block the children had to match the stimulus by colour for five test trials. The child had to get 4 out of 5 correct to move onto the Post-switch block, otherwise the test terminated. In the Post-switch block, the child had to sort the stimulus by shape and again get 4 out of 5 in order to move onto the Mixed block; otherwise the test was terminated. In the Mixed block, the dimension by which the child had to match the stimulus alternated between colour and shape for 30 trials as in the adult version of the task. The scoring for DCCS was the same as described for the Flanker test. Higher scores indicate better cognitive flexibility. This measure has high

reliability and convergent validity with developmental sensitivity throughout childhood (Weintraub et al., 2013; Zelazo et al., 2013).

***Episodic Memory*.** PSMT, Form A was used for the current study. In the Training session, the research assistant demonstrated how to move the pictures that appeared on the screen between yellow and gray boxes. The children were administered two Practice rounds. During these rounds, in the yellow box, the child was presented with a sequence of pictures, shown one at a time, describing an event (e.g. Having a Birthday Party, Going Camping). The pictures were then scattered within the yellow box and the child was instructed to organize the pictures in the same sequence in the gray boxes beneath the yellow box. The child was given four trials for each practice round. If they failed all four trials of a given practice round, the test was discontinued. Those who proceeded to the test round completed two trials of a 9-step sequence (i.e. How to play in the park). The test ended once the two trials were completed. Based on item response theory, a theta score (representing the overall performance of child) was generated from the number of adjacent pairs of pictures placed correctly in each of the two trials. The score was adjusted for age based on normative data. Higher scores indicate better episodic memory ability (Slotkin et al., 2012). The PSMT has demonstrated high test-retest reliability and construct validity (Bauer et al., 2013; Dikmen et al., 2014).

Backward Digit Span (BDS). Children completed the BDS as a measure of working memory (Carlson, 2005). Children were informed that they were going to play a game where the experimenter says a sequence of numbers and the child had to repeat them backwards. Three practice rounds with three trials each were provided with only 2 digits. For each incorrect response, the rules were repeated for the child. The child proceeded to the test rounds regardless of their performance in the practice rounds. The test rounds began with two digits and increased

in the number of digits in subsequent trials. Each trial was composed of two items (i.e. two sets of numbers). The test was terminated when the child gave incorrect responses for both items in a trial. The final scores included the longest digit sequence (e.g. 3 digits) attained, as well as total number of correct items. The total number of correct items was used in the current study.

Simon Says. Children completed Simon Says as a measure of inhibition (Strommen, 1973). Prior to starting the game, the research assistant instructed the child: "So before we start the game, we're going to practice. So, stand in front of me, facing me, and whatever silly thing I do, you do too! Let's try it out!" The research assistant went through 10 rounds of commands including: "Touch your nose" and "Wave your hand." Once completed, the research assistant informed the child that they were going to begin the game. The child was instructed to follow the action of the experimenter only if the command was prefaced with 'Simon says' (directive trials). However, if the experimenter didn't say 'Simon says' prior to giving a command, the child was instructed to not follow the action of the experimenter (inhibition trials). During the practice rounds, if the child provided an incorrect response, the rules were repeated, and another practice trial was conducted with a different action. These practice trials continued for an unlimited number until the child performed the correct response to the inhibition trial without prompting. Ten test trials were conducted in total with five 'directive' trials and five 'inhibition' trials. Children were scored based on performing no movement, partial movement, incorrect movement or complete movement (depending on the trial type – directive or inhibition) with scores ranging from 0 to 3.

Child Verbal Abilities

Children completed the Picture Vocabulary Test assessing their receptive vocabulary (Gershon et al., 2013) derived from the NIH Toolbox Cognition Battery. The research assistant

provided the first set of instructions verbally as they appeared on the screen. All other instructions during the practice and test trials were pre-recorded. The child was told that they will hear a word and see four pictures depicting images, actions or concepts appear on the screen. They were instructed to click on the picture that represented the meaning of the spoken word. The child was presented with two practice trials with three chances for each trial. If they answered incorrectly, the research assistant clicked the correct picture for them and reviewed the instructions. The test trials consisted of 25 rounds. Using Computer Adaptive Testing (CAT), the difficulty of the pictures presented was automatically adjusted based on the performance of the child. There was no time limit for each test trial. Based on item response theory, a theta score (representing the overall performance of child) was computed for each child and adjusted based on normative data to account for age. Higher scores indicate higher verbal ability (Slotkin et al., 2012). The measure has been reported to have high test-retest reliability, as well as strong convergent and discriminant validity (Gershon et al., 2013; Zelazo et al., 2013).

Maternal Depression

Mothers completed the 20-item Center for Epidemiologic Studies-Depression Scale (CES-D; Radloff, 1997) as a measure assessing depressive symptomology over the previous week. The clinical cut-off was a score of 16 or higher. Higher scores indicate higher levels of depressive symptomology. The CES-D has demonstrated high internal consistency and test-re-test reliability as well as adequate internal, concurrent and predictive validity with clinical ratings of depression and related self-report measures (Radloff, 1997). The measure for the present sample demonstrated good internal consistency (Cronbach's α= .89).

Statistical Analyses

Descriptives and bivariate correlations were examined for all study variables and covariates and are reported in Table 1. All analyses were conducted using Mplus 8.3 (Muthén & Muthén, 1998-2017). Outcome variables were log transformed and winsorized prior to analyses (if needed) to correct for non-normal distributions where an outlier beyond three standard deviations existed. Two composite variables were included in the analysis, household chaos and parenting. Variables were transformed into Z scores (with mean zero and standard deviation one) and summed following the recommendation of simple averaging (Song, Lin, Ward, & Fine, 2013). The conversion of Z scores permits equal contribution of each variable to the composite via preserving the distribution of the scores each included variable. For the household chaos composite a number of variables were included to account for its two dimensions: disorganization and instability. For the disorganization dimension, we included the total score for the CHAOS Scale and the word frequency count from the LIWC software referencing clutter, ambient noise and lack of structure in the home scores from the transcripts. These two measures were combined to create a 'disorganization' composite. For the instability dimension, we included the FILE item (i.e. changes in relationship status in past year), the residential mobility variable (i.e. number of moves in past five years) and the word frequency count from the LIWC software referencing caregiver changes, residential changes, frequent visitors in and out of home and unpredictable routines from the transcripts. These measures were combined to create an 'instability' composite. Both the 'disorganization' and 'instability' variables were combined into a composite to represent a 'household chaos' construct. The parenting composite included total scores for cognitive sensitivity and emotional availability which were positively and significantly correlated (r = .57).

The measurement model for child executive functions (latent construct) was examined using confirmatory factor analysis (CFA) with the Z scores of the indicators: Backward Digit Span, Simon Says and the NIH toolbox cognition battery composite (i.e. age-adjusted scores for Flanker test, DCCS, PSMT). Structural equation modeling was used to assess the direct effects of household chaos on child executive functioning and the indirect effects via parenting behaviours (Model 1). Specifically, the total effect between household chaos and child executive functions (without parenting) and the direct effect between these variables (with parenting) were examined. Examination of the indirect effects (i.e. effect of household chaos on child executive functions through parenting) followed the recommendation of using bias-corrected bootstrap confidence intervals (CIs) which accounts for non-normality of estimates and provides the greatest statistical power (Fritz & MacKinnon, 2007; MacKinnon, Lockwood, & Williams, 2004). This is established via drawing resamples with replacement from the observed dataset (5,000 draws in the current study) and then estimating the indirect effect for each sample which are used to generate bias-corrected confidence intervals. This method is recommended for indirect effect models with small to moderate sample sizes (Shrout & Bolger, 2002). A bias-corrected confidence interval that does not include zero indicates the indirect effect is statistically significant. Standardized estimates were reported. Covariates included were selected based on theoretical considerations and model parsimony: household income (combined maternal and paternal salaries), sex of child (coded as 1 = male, 0 = female), maternal depression (CES-D) and maternal executive functioning (NIH Toolbox Flanker and DCCS). A series of secondary analyses were conducted. First, we examined the differential effects of each dimension of household chaos on child executive functioning via parenting. Model 2a involved the association between household disorganization and child executive functions via parenting.

Model 2b involved the association between household instability and child executive functions via parenting. Second, we analyzed the indirect effects model (with original paths retained from Model 1) separately in male and female children (Models 3a-b). Finally, a sensitivity analysis was conducted to see if the associations within the indirect effects model (Model 1) persisted after controlling for child verbal ability. This accounts for theoretical rationale (Hughes & Ensor, 2009) and empirical findings (Matte-Gagné & Bernier, 2011) that child verbal ability contributes to the association between parenting and child executive functioning. Measurement and structural models were assessed using the following indices of model fit: the likelihood ratio chi-square test, comparative fit index (CFI) and root mean squared error of approximation (RMSEA). As per standard recommendations, a non-significant chi-square test, as well as values greater than .95 for CFI and less than .05 for RMSEA are considered indicative of good model fit (Hu & Bentler, 1999).

Missing data

Missing data ranged from 9.6 to 15.1% for main study variables. Full Information Maximum Likelihood Estimation (FIML) (Muthén & Muthén, 2017) within the structural equation modeling framework was used to account for missing data and non-normal distribution. This approach is considered to be superior to other traditional methods (i.e. listwise deletion, pairwise deletion, multiple imputation; Enders & Bandalos, 2001) as it retains statistical power and produces unbiased estimates.

Results

Descriptive Statistics

Means and standard deviations for main study variables as well as bivariate correlations are presented in Table 1. Each of the indicators of child executive functioning were positively

correlated with one another. Parenting was positively correlated with each of the child executive function indicators. Neither of the dimensions of household chaos were significantly correlated with either the indicators of child executive functioning or parenting. The composite of household chaos, however, was significantly associated with parenting in the negative direction.

Table 1. Means, standard deviations and bivariate correlations for main study variables and covariates.

Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10	11
1. NIH toolbox cognition composite	104.10	15.05	1	.21*	.26**	-.11	.03	-.13	.27**	.06	.04	.26**	-.13
2. Backward Digit Span	3.62	1.76	.21*	1	.42**	-.14	-.05	-.06	.22**	.05	.12	.02	-.01
3.Simon Says	43.60	10.43	.26*	.42**	1	-.10	.001	-.17	.19*	.06	.06	.23*	-.04
4.Household Chaos	0	.69	-.11	-.14	-.10	1	.74**	.50**	-.20*	-.05	.38**	-.16	-.02
5.Household disorganization	.01	.77	.03	-.05	.001	.74**	1	-.09	-.12	-.07	.34**	-.04	-.07
6.Household instability	0	.72	-.13	-.06	-.17	.50**	-.09	1	-.09	-.03	.09	-.08	.08
7.Parenting	0	.89	.27**	.22*	.19*	-.20*	-.12	-.09	1	.11	-.17	.14	.06
8. Maternal Executive Function	0	.88	.06	.05	.06	-.05	-.07	-.03	.11	1	-.17	.07	.10
9. Maternal depression	7.79	7.28	.04	.11	.06	.38**	.34**	.09	-.17	-.17	1	-.29**	-.08
10. Household income (median, CAD)	$105,000 – 133, 499		.25**	.02	.23*	-.16	-.04	-.08	.14	.07	-.29**	1	-.12
11. Sex of Child (%)	49		-.13	-.01	-.04	-.02	-.07	.08	.06	.10	-.08	-.12	1

* $p < .05$, ** $p < .01$

Descriptive statistics for the video home tours are shown in Table 2. Word counts generated by LIWC represent the number of words in a category as a percentage of the total number of words in a transcript. Each word in the dictionary was used at least once in two distinct home tours. The mean base rate was 26% meaning that approximately 33 of 128 tours included words from both disorganization and instability categories. The disorganization

category was more frequently discussed in home tours with the most widely used words related to clutter (75 tours).

Table 2. Percentage of words in home tour custom categories for household chaos construct.

Category	Disorganization	Instability
Words included	chao*; clutter*; disarray; disast*; disorganiz*; hoard*; mess*; nois*; reno*; unclean; unfinished; untidy	attempt; entertaining; guests; new residence; novel; separation; visit*
Min to max	0 to 2.41	0 to 1.92
Mean	.35	.15
Median	.25	0
Standard deviation	.43	.30

Household Chaos, Parenting and Child Executive Functions

If the number of parameters to be estimated is equal to the number of data points, the model is just identified and hypothesis about the adequacy or fit of the model cannot be tested (Tabachnick & Fidell, 2019). Though the current model met the minimum of having 3 indicators for a measurement model, and the parameters had meaningful estimates, the model was just-identified and there were not enough degrees of freedom to estimate the fit. As an alternative, to assess reliability of the indicators, Cronbach's alpha was calculated, and the model demonstrated moderate reliability ($\alpha = .58$). The indicators were positive and loaded significantly onto the construct (Figure 1).

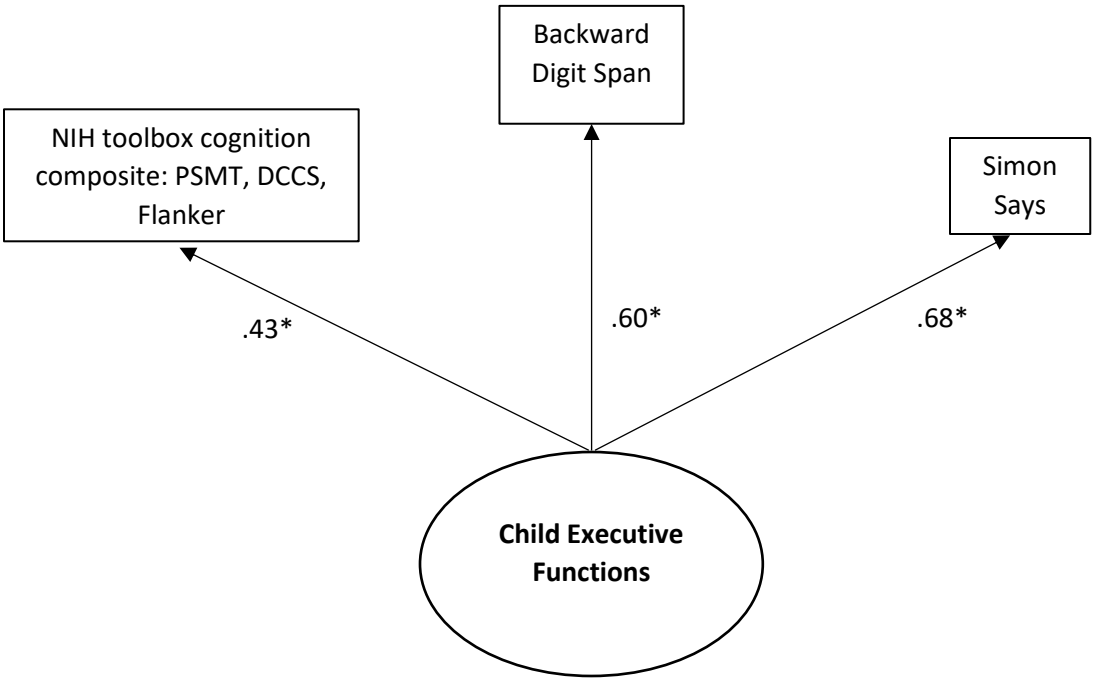

Figure 1. Measurement model for latent construct of child executive function.

Note: Standardized loading coefficients shown.

The structural equation model examining the indirect path from household chaos to child executive functions via parental behaviours demonstrated excellent model fit (n = 128, χ^2 (19) = 14.2, p = .77; RMSEA = .00; CFI = 1.00). The total effects from household chaos to child executive function (without parenting) was significant (path c: β = -.33, 95% CI [-.56, -.11]). Greater household chaos was significantly associated with lower parenting scores (path a: β = -.18, 95% CI [-.33, -.02]). A significant positive association was found between parenting and child executive functioning (path b: β = .27, 95% CI [.07, .47]). The negative association between household chaos and child executive functioning remained significant with the addition of parenting (direct effects) (path c': β = -.31, 95% CI [-.59, -.04]). Finally, the indirect effect of household chaos on child executive functions via parenting was also significant (path ab: β = -

.05, 95% CI [-.13, -.01]). Income was the only significant covariate in the model (β = .32, 95% CI [.05, .59]). Overall the model explained 29% of the variance in the latent construct of executive functions. The visual representation of structural equation model is presented in Figure 2.

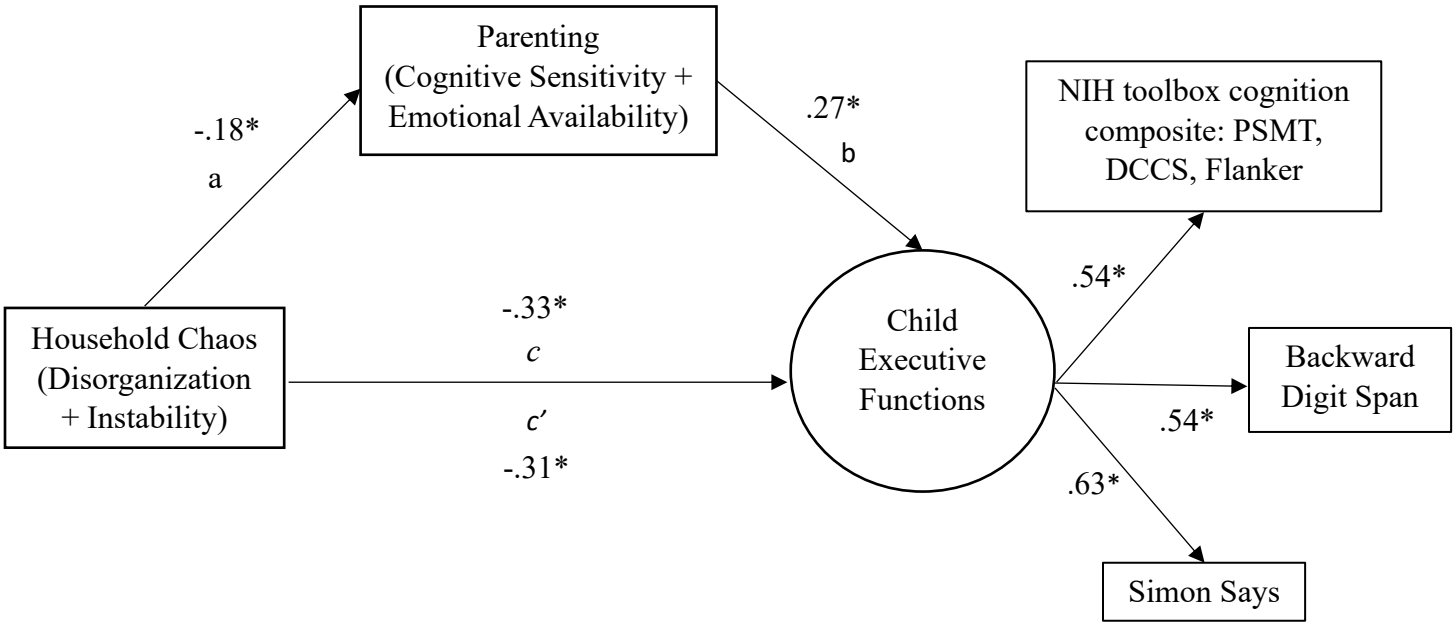

Figure 2. Structural equation model of the direct and indirect (via parenting) effects of household chaos on child executive functions.

Note: Standardized loading coefficients shown.

Household Disorganization and Instability

The unique effects of the dimensions of household chaos were assessed via secondary analyses (Models 2 a-b). Standardized coefficients of all paths are presented in Table 3. The total effect of disorganization on child executive functioning was not significant (path c: β = .-.12, 95% CI [-.35, .11]). The indirect effect of household disorganization on child executive functions via parenting was then assessed. The model fit was excellent (n = 128, χ^2 (19) = 15.34, p = .70;

RMSEA = .00; CFI = 1.00). However, there were no significant direct or indirect effects of household disorganization on child executive functions. Income was the only significant covariate in the model (β = .32, 95% CI [.04, .59]). Overall the model explained 21% of the variance in the latent construct of executive functions.

For household instability, the total effect of instability on child executive functions was significant and in the negative direction (path c: β = -.30, 95% CI [-.52, -.08]). Next, the indirect effect of household instability on child executive functions via parenting was examined. There was a significant indirect effect of instability on child executive functions via parenting and the direct effect between household instability and child executive functions remained significant with the addition of parenting. Again, model fit was excellent (n = 128, χ^2 (19) = 15.96, p = .66; RMSEA = .00; CFI = 1.00) and income emerged as the only significant covariate in the model (β = .29, 95% CI [.03, .55]). Overall the model explained 28% of the variance in the latent construct of executive functions.

Table 3. Structural model parameter estimates for household disorganization, household instability, parenting and child executive functions (Model 2a and 2b).

Model 2a	**Standardized Coefficient**	**95% CI**
Household disorganization → child executive functions (path c')	-0.12	[-.43, .16]
Household disorganization → parenting (path a)	-0.08	[-.23, .07]
Parenting → child executive functions (path b)	**.30**	**[.08, .50]**
Household disorganization → parenting → child executive functions (path ab)	-.02	[-.09, .02]
Model 2b		
Household instability → child executive functions (path c')	**-.28**	**[-.54, -.01]**
Household instability → parenting (path a)	**-.17**	**[-.33, -.002]**
Parenting → child executive functions (path b)	**.27**	**[.07, .47]**
Household instability → parenting → child executive functions (path ab)	**-.05**	**[-.13, -.004]**

Note: bolded effects are significant.

Sex-Based Effects

To determine potential child sex effects, the association between household chaos, parenting and child executive functions was examined separately in male (Model 3a) and female (Model 3b) children. Standardized coefficients of all paths are presented in Table 4. For male children, the model fit was good (n = 66, χ^2 (16) = 17.49, p = .35; RMSEA = .04); CFI = .95). The total effect from household chaos to child executive functions (without parenting) was not significant (path c: β = -.24, 95% CI [-.64, .16]. Further, while the indirect effect was significant, the direct effect was not significant demonstrating a 'full' or 'indirect only' association (Baron & Kenny, 1986; Zhao, Lynch, & Chen, 2010). Income (β = .46, 95% CI [.14, .77]) and maternal executive functioning: (β = .44, 95% CI [.11, .77]) were the only significant covariates. Overall the model explained 43% of the variance in the latent construct of executive functions. For female children, model fit was excellent (n = 62, χ^2 (16) = 11.20, p = .80; RMSEA = .00, CFI = 1.00). The total effect from household chaos to child executive functions (without parenting) was not significant (path c: β = -.33, 95% CI [-.67, .01]). Also, neither direct nor indirect effects of household chaos were significant. No covariates emerged as significant. Overall the model explained 21% of the variance in the latent construct of executive functions.

Table 4. Structural model parameter estimates for household chaos, parenting, and child executive functions in male and female children (Models 3a and b).

Model 3	**a. Male Children**		**b. Female Children**	
	Standardized Coefficient	**95% CI**	**Standardized Coefficient**	**95% CI**
Household chaos → child executive functions (path c')	-.27	[-.61, .11]	-.30	[-.91, .30]
Household chaos → parenting (path a)	**-.22**	**[-.42, -.01]**	-.14	[-.36, .12]
Parenting → child executive functions (path b)	.27	[-.03, .57]	.26	[-.05, .59]
Household chaos → parenting → child executive functions (path ab)	**-.06**	**[-.25, -.003]**	-.04	[-.18, .02]

Note: bolded effects are significant

Sensitivity Analysis

In the sensitivity analysis, the model fit remained good with the addition of child verbal ability as a covariate (n=128, χ^2 (22) = 24.929, p = .301; RMSEA = .032; CFI = .969) and all paths in the model remained significant. Household chaos was directly (path c': β = -.26, 95% CI [-.49, -.04]) and indirectly (via parenting; path ab: β = -.04, 95% CI [-.11, -.01]) associated with child executive functions. Significant covariates included: child verbal ability (β = .69, 95% CI [.46, .87]) and maternal depression (β = .24, 95% CI [.03, .48]). Notably, the overall model with the inclusion of child verbal ability explained 70% of the variance in the latent construct of executive functions.

Discussion

The aim of the current study was to investigate parenting as a mechanism through which household chaos affects child executive functioning. Using novel, multi-method approaches, our findings indicate that greater household chaos was directly associated with lower performance on child executive functioning tasks, and indirectly, via lower maternal cognitive sensitivity and emotional availability. Separating the dimensions of household chaos revealed that instability, and not disorganization, had a negative impact on child executive functioning both directly and indirectly via parenting. Further, significant indirect effects were only found for male children, while no significant direct or indirect effects were found for female children.

The direct associations are consistent with the literature such that greater chaos in the home has been linked to poor executive functions as measured by performance based tasks (Brown, Ackerman, & Moore, 2013; Hughes & Ensor, 2009; Peviani et al., 2019) and questionnaires (Andrews, Atkinson, Harris, & Gonzalez, 2020; Dumas et al., 2005; Evans, Gonnella, Marcynyszyn, Gentile, & Salpekar, 2005). Studies have demonstrated the stability of

household chaos over time (e.g. Deater-Deckard et al., 2009; Hart, Petrill, Deckard, & Thompson, 2007; Zvara et al., 2014). Given this demonstrated consistency, it is possible, that the direct effects demonstrated in the current study reflect the result of children learning over time to withdraw from environmental stimuli that may be uncontrolled (Evans, Kliewer, & Martin, 1991; Vernon-Feagans et al., 2016). While protective against threats, this can also prevent them from exposure to more positive influences that can aid in their cognitive development. Further, children may not have the capacity to filter irrelevant stimuli that may be overwhelming or distracting (e.g. ambient noise; Lillard et al., 2015; Wachs & Evans, 2010) which may have implications for the development of their executive functions.

Indirect Effects of Household Chaos on Child Executive Functions

To our knowledge, only one study to date has formally examined the indirect effects of household chaos on child executive functioning via parenting (Vernon-Feagans et al., 2016); making the findings of the current study particularly important to our understanding of this mechanism. The general findings are aligned with that of the current study where greater household chaos is associated with lower levels of positive parenting practices (i.e. cognitive sensitivity and emotional availability for the current study; acceptance and responsiveness for Vernon-Feagans et al., 2016), which is related to poor executive functioning in their children. Chaotic homes may disrupt a parent's ability to regulate their own affect which can reduce their ability to engage in sensitive interactions with their child (Evans, 2004); potentially resulting in their use of harsher practices (Coldwell et al., 2006). These compromised interactions can negatively affect the child's executive function development (Bernier et al., 2012). Others have examined parenting and household chaos as separate predictors of child executive functioning with similar effects, reflecting the importance of both of these factors. Positive parental support

(i.e. involvement, proactivity, positive behaviour support, engagement) experienced at the age of three in a high risk preschool sample was positively associated with inhibitory control at age four; whereas household chaos had a negative effect (Hardaway et al., 2012). Ultimately, given the growing number of longitudinal studies examining parenting as a mediating factor between cumulative exposure of household chaos and child outcomes (e.g. Evans et al., 2010; Mills-Koonce et al., 2016; Vernon-Feagans et al., 2016), it is evident that understanding how chaotic homes modulate the quality of parent-child interactions can inform programs aimed at supporting children and families. Further, more studies are examining these proximal processes within adolescent populations as well (e.g. Deater-Deckard et al., 2019; Kahn, Deater-Deckard, King-Casas, & Kim-Spoon, 2016; Lauharatanahirun et al., 2018; Tucker, Sharp, Gundy, & Rebellon, 2018), suggesting that longitudinal studies extending from childhood to adolescence can help to better understand the sustainability of these associations and identify possible factors that may act to either exacerbate negative associations or mitigate their effects. This is particularly important given the protracted development of the PFC and the vulnerability of executive function development to contextual risks such as household chaos (Pechtel & Pizzagalli, 2011; Teicher et al., 2003).

Household Instability

Household instability emerged as an important adverse predictor of child executive functioning both directly and indirectly via parenting. The direct associations between household instability and child executive functioning is aligned with other studies (Andrews et al., 2019; Brown et al., 2013; Schmitt et al., 2015). For example, a lack of routine in early childhood has been linked to poor performance on delayed gratification tasks in school-aged children (Martin, Razza, & Brooks-Gunn, 2012). Another six year study showed higher emotional self-regulation,

less alcohol use, lower epinephrine levels and greater rates of entering post-secondary education in youths who were exposed to more routines (i.e. eating meals as a family, consistent bedtime) (Barton et al., 2018). The current study further corroborates the notion that even with limited exposure to instability, the subsequent disruption can still be quite impactful. This is based on the fact that this sample can be considered fairly low risk for instability (i.e. only approximately 8% of children were exposed to a change in caregiver within the previous year, 46% had experienced one or more residential moves within the past 5 years and only 33% making some reference to instability - unpredictable routines, frequent visitors in and out of the home - in the home tours). It is possible that the unpredictability within the home minimizes a child's control over their environment and instills a sense of helplessness (Evans et al., 2005; White, 1959). This could hinder the child's ability to manage their affect and behaviours, which are potentially related to underlying deficits of executive functioning.

Interestingly, only one to date has examined the differential effects of chaos dimensions in this indirect effects model and found that household disorganization, and not instability, indirectly predicted child regulatory behaviours via parenting (Vernon-Feagans et al., 2016). It may be that since instability was measured at an earlier age (i.e. 2-36 months), transitions such as residential moves may not have been as disruptive. The current study, however, includes school-aged children who may be beginning to establish ties to their community, peers and school (Brooks-Gunn et al., 2010). Parenting likely plays an important role in determining how the child is affected by these transitions. For example, greater numbers of co-residential and dating transitions were found to be positively associated with maternal stress and harsh parenting (Beck, Cooper, McLanahan, & Brooks-Gunn, 2010). Relatedly, significant negative linkages have been made between instability (i.e. caregiver and relationship changes, job/income loss or changes,

residential mobility) and maternal supportive parenting, which in turn, was negatively associated with child externalizing behaviour problems as they entered kindergarten (Coe, Davies, Hentges, & Sturge-apple, 2019). One may postulate, then, that transitions and a lack of routines may not only create an atmosphere of unpredictability for the child but also the parent. Each transition may force the parent to adjust to a new setting, partner (or loss of one) and/or routine (Fomby & Cherlin, 2007). If the parent is unable to regulate their own affect, cognitive functioning and behaviours in response to such transitions, possibly due to depleted energy, increased frustrations or preoccupations, (Forman & Davies, 2003) this may negatively impact their interactions with their child. Indeed, consistent and sensitive parenting is considered a buffer against the effects of instability on child executive functioning, particularly given that sensitive and responsive parenting has the capacity to protect child development and promote resilience in the face of contextual risk factors (Masten & Gewirtz, 2006). Future replication studies should examine additional factors that could be influencing these complex indirect effects of household instability on child executive functioning via parenting such as the effects of the distance of residential moves (Tiesler et al., 2013), the quality of the transitions (Anderson, Leventhal, & Dupéré, 2014; Roy et al., 2014), and the timing of transitions (Anderson & Leventhal, 2016).

Household Chaos and Sex Differences

Unique indirect effects of household chaos on child executive functioning via parenting were found for male children only. No direct or indirect effects were found for female children. Notably, the current study is the first, to our knowledge, to explicitly examine possible sex-based differences in regard to the effects of household chaos, on parenting and child executive functioning. Direct effects were not found for male or female children which is aligned with the literature (Andrews et al., 2020; Pike, Iervolino, Eley, Price, & Plomin, 2006; Shamama-tus-

sabah & Gilani, 2012). The indirect effects for male children only, however, raises the question of the role that gender-differentiated parenting may play in this association. One study found that reports of high chaos in the home were linked to male parents using harsh physical discipline against their male children more than against their female children, and mothers showing less support for their male children (Cabrera, Bradley, Shannon, & Hancock, 2017). Some studies, however, have suggested that male children are generally more vulnerable to contextual risk than their female counterparts. Male children, for example, tend to take longer than female children to adjust to familial transitions; which can be exacerbated if exposed to multiple transitions (Cavanagh et al., 2008). Also, early exposure (birth to age five years) to frequent changes to maternal partners in dating or co-residential relationships was more strongly linked to externalizing problems in males than females (Cooper, Osborne, Beck, & McLanahan, 2011); and relatedly, co-residential relationships also strongly predicted attentional problems in male children more than females. Still other studies find minimal or no sex differences. For example, a recent meta-analysis assessing possible differential use of autonomy-supportive and controlling strategies by mothers and fathers with male and female children found that slightly more controlling behaviours were used for male children than females, however effect sizes were considered to be negligible (d = .08; Endendijk, Groeneveld, Bakermans-Kranenburg, & Mesman, 2016). Another study, using an adolescent sample, found that housing disorder (i.e. structural deficiencies, poor cleanliness) heightened parental distress which was associated with higher frequency of harsh, inconsistent discipline and less warmth, which in turn predicted greater internalizing and externalizing behaviours (Jocson & Mcloyd, 2015). However, the paths between these variables did not vary significantly based on the sex of the child, suggesting equal effects for males and females. Evidently, the extant literature is equivocal indicating that further

research examining possible sex differences in how children's exposure to household chaos and parenting challenges affects their executive functioning is needed.

Strengths and Limitations

The current study adds pertinent findings to the growing body of literature examining the associations between household chaos, parenting and child executive functioning. The novel, multi-method approach (i.e. self-report, home tours, direct assessments, video-taped interactions) of this study is an asset as it provides a level of objectivity through which the findings can be interpreted. For example, our use of video-taped interactions to assess parenting allows mitigation of possible shared method variance that could have been an issue with previous studies largely using reports to assess chaos and parenting. The current study also considered and controlled for maternal characteristics that could be affected by household chaos and impact their interactions with their child including mood (Hur et al., 2015) and executive functioning (Deater-Deckard, Wang, Chen, & Bell, 2012), where previous studies have focused on controlling SES factors only. With that said, this study is not without its limitations. The cross-sectional design prevents assessment of the effects of household chaos over time. Few studies have demonstrated the stability of household chaos over time (e.g. Deater-Deckard et al., 2009; Hart et al., 2007; Vernon-Feagans et al., 2016). Similarly, though even small doses of instability can be impactful – assessing cumulative effects on parenting and the development of child executive functioning should be a future research direction. Furthermore, it would provide greater insight into the directionality of effect where possible reciprocal associations between household chaos and parenting and parenting and child executive functions could be thoroughly assessed. Additionally, it is important to note that this was a low risk, ethnically homogenous sample which may influence the generalizability of the results.

Conclusion

This study provides a novel, multi-method approach to examining associations between household chaos, parenting and child executive functioning. It highlights parenting as an important factor facilitating the impact of household chaos on child executive functioning. Future research should examine specific maternal characteristics that may contribute to a mother's ability to navigate the dynamics of the home and their interactions with their child (i.e. maternal mood, affect and stress physiology). It also brings attention to the importance of structure, predictability and routines within the home on the development of child executive functions, which has implications for future self-regulation and school readiness (Blair & Raver, 2015). Both parenting and stability within the home would be important targets for interventions that could act to promote healthier developmental trajectories for children. This may involve further investigation into factors that may help to buffer the negative effects of household chaos on parenting and child outcomes (e.g. structured child-care). Furthermore, while this study does not permit conclusive arguments regarding sex differences in the context of household chaos, parenting and executive function, it does bring attention to the current gap in the literature and the disparities within extant findings. Ultimately, these findings can potentially inform the development of preventative strategies for children and their families aimed at improving parenting and providing greater stability within homes.

Chapter 4: Study 3

General Purpose

Maternal distress has been demonstrated to have direct negative effects on child cortisol levels (Apter-Levi et al., 2016; Palmer et al., 2013) and socioemotional functioning (Goodman et al., 2011; Yoo et al., 2014). Previous studies that have examined the mechanism through which maternal distress exerts its effects have explored the role of parenting as a mediator. However, only one study, to the best of my knowledge, has considered the influence parents have the home environment which can subsequently impact child behaviours (Hur et al., 2015). Parents have the capacity to organize the home and create stability via relationships, routines and rules. The objective of this third study is to explore the direct and indirect effects of maternal distress, as measured by depressive symptomology, negative affect and chronic stress, on child hair cortisol levels and externalizing and internalizing behaviour problems. Further examination of the role of the different dimensions of household chaos – disorganization and instability – as a mediator in this indirect mechanism will also be explored.

Title and Authorship

Title: Examining the impact of maternal distress and household chaos on child hair cortisol levels and socioemotional functioning: A novel, multi-method approach

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Conflicts of Interest: None

Abstract

Maternal distress can adversely affect the stress physiology and socioemotional functioning of children. Minimal research has been done to examine the potential role that the home environment may play in mediating the effects of maternal distress on these child outcomes. Parents have the capacity to manage the level of order and stability in the home which may be undermined with the presence of depression, negative affect and chronic stress which may subsequently affect child functioning. As such, the objectives of the present study were two-fold: 1) to examine the potential direct and indirect effects (via household chaos) of maternal distress on child hair cortisol levels and externalizing and internalizing behaviour problems; and 2) explore the differential effects of maternal distress on each dimension of household chaos (disorganization and instability) in the indirect effect mechanism. Data were derived from a sample of 125 school-aged children (49% female) and their mothers in the Hamilton, ON region. Household chaos was measured in multiple, novel ways: 1) the Confusion, Hubbub, and Order Scale (CHAOS); 2) self-report of number of residential moves and caregiver changes; and 3) a maternal guided tour of the home, scored for household chaos-related variables via Linguistic Inquiry and Word Count software. Maternal distress was comprised of three measures: 1) depressive symptoms were measured via the Center for Epidemiologic Studies-Depression Scale (CES-D); 2) negative affect was measured via word frequency count of negative affect-related words in the home tours; and 3) hair samples were collected from the mother from which the stress hormone, cortisol, was extracted as a biomarker of chronic stress. The ASEBA® Child Behavior Checklist was used to assess child externalizing and internalizing behaviour problems; completed by mothers. Hair samples were also collected from children. Structural equation modelling of direct and indirect effects (via household chaos) of a linear regression-weighted

composite of maternal distress on child hair cortisol levels and externalizing and internalizing behaviour problems was examined using version 8.3 of Mplus software. Covariates included income, child gender, parenting and maternal executive functions. The results indicated maternal distress had both direct (β = .36, 95% CI [.16, .54]) and indirect effects (via household chaos) (β = -.11, 95% CI [-.19, -.02]) on child hair cortisol levels. Indirect effects, only, were found for child externalizing (β = .18, 95% CI [.10, .29]) and internalizing (β = .12, 95% CI [.03, .21]) behaviour problems. Further disorganization, but not instability, significantly mediated the association between maternal distress and hair cortisol levels (β = -.18, 95% CI [-.34, -.07]), externalizing β = .25, 95% CI [.13, .41]) and internalizing (β = .15, 95% CI [.04, .29]) behaviour problems. These findings highlight the effect that maternal physiological and mental health can have in regulating the organization of the home. Future research needs to develop and evaluate interventions geared towards supporting maternal health and fostering order in the home to promote healthy child functioning.

Introduction

Maternal distress broadly reflects inputs from multiple aspects of a mother's experience including personality characteristics, mood, family climate and sources of stress and support, all of which collectively contribute to the overall functioning of mothers (Belsky, 1984). The operationalization of maternal distress has varied in the literature with most studies including measures of depression, anxiety and stress (Barry, Dunlap, Cotten, Lochman, & Wells, 2005; Nilsen, Gustavson, Røysamb, Kjeldsen, & Karevold, 2013; Whitesell et al., 2015), and others including negative emotional bias (Yoo et al., 2014), quality of life (Doyle et al., 2017), and relationship quality (Bennett & Kearney, 2018). Single indicators of maternal distress do not fully elucidate the notion of distress as a construct which may encompass multiple factors and offer a more ecologically informed view of the experience of distress (Yoo et al., 2014). Beyond its effects on the mother, maternal distress has significant and widespread impacts on the development and functioning of offspring both directly and indirectly. For the purposes of this study, our composite of maternal distress included measures of depression, negative affect and physiological stress. We were interested in examining the direct association of maternal distress on socioemotional functioning and chronic stress measures in school-aged children, and the indirect association via household chaos.

Maternal Distress and Child Outcomes: Socioemotional Functioning and Stress Physiology

Various aspects of maternal distress have been associated with externalizing (e.g. aggression, impulsivity) and internalizing (e.g. social withdrawal, anxiety) behaviour problems in children. Positive associations between cumulative maternal distress, which included measures of negative affect, marital satisfaction and family functioning, and externalizing behaviour problems have been demonstrated in school-aged children (Yoo et al., 2014). Maternal reports of

both major life events and daily stressors also increased the likelihood of externalizing behaviours in offspring (Crnic et al., 2005). Further, a meta-analysis found small but significant effect sizes between maternal depression and both child externalizing (r = .21) and internalizing (r = .23) behaviour problems (Goodman et al., 2011). Notably, effects were stronger for younger children (Goodman et al., 2011), likely due to their dependence on their caregivers (Cummings, Keller, & Davies, 2005). Collectively these findings highlight the importance of identifying mechanisms underlying the association between maternal distress and child behaviour problems during early childhood.

Maternal distress has also been linked to child stress physiology. Activation of the hypothalamic-pituitary-adrenal (HPA) axis results in a cascade of processes that leads to the release of cortisol, a human glucocorticoid hormone (Gunnar & Quevedo, 2007; Miller et al., 2007). While adaptive to acute stressors (McEwen, 2005), chronic activation due to repeated adversities may dysregulate a child's still developing stress response with implications for their overall functioning (Danese & McEwen, 2012; Hertzman & Boyce, 2009). This dysregulation was demonstrated in a study with a school-aged (approximately six years old) sample of children who, during a home visit, were administered two empathy paradigms exposing them to simulated distress from the experimenter (Apter-Levi et al., 2016). Saliva samples were collected before and after the paradigms were administered and demonstrated that children of chronically depressed mothers showed less flexible HPA axis activity (i.e. upregulated cortisol levels) (Apter-Levi et al., 2016). A recent longitudinal study followed mothers and their children from birth to age ten (Ulmer-Yaniv, Djalovski, Priel, Zagoory-Sharon, & Feldman, 2018). At age ten, saliva samples were taken at three points during the home visit and revealed positive associations

between maternal depression and salivary diurnal cortisol levels in children, which in turn, was positively associated with greater behavioural problems (Ulmer-Yaniv et al., 2018).

Cortisol extraction from biological specimens such as saliva, urine and plasma provide a transient measure of stress and therefore cannot assess the chronicity of stress in children (Short et al., 2016). Hair cortisol is considered a reliable marker of chronic stress (Russell et al., 2012) as it averages daily circulating cortisol fluctuations (Adam, Hawkley, Kudielka, & Cacioppo, 2006; Bates, Salsberry, & Ford, 2017). Further it has been validated within preschool (Vaghri et al., 2013) and elementary school (Vanaelst et al., 2012) samples. Few studies, have examined the effect of maternal distress on hair cortisol (e.g. see for review, Gray et al., 2018), however, to our knowledge, none to date have looked at these associations in school-aged children. In adolescents, no significant associations were found between self-reported maternal stress and adolescent hair cortisol levels (Olstad et al., 2016). In infants, the findings are mixed: with some demonstrating no significant association between self-reported maternal stress and depressive symptoms and infant hair cortisol levels (Flom, St. John, Meyer, & Tarullo, 2017; Liu et al., 2016) and another reporting positive associations between maternal reported stress and infant hair cortisol concentration, but an inverse association between the infant hair cortisol concentration and maternal self-reported depressive symptoms (Palmer et al., 2013). Given the dearth in research examining these associations within school-aged children, the current study provides needed insight into the impact of maternal distress on more chronic measures of child stress physiology.

An Indirect Mechanism: The Role of Household Chaos

Despite established direct linkages between maternal distress and child socioemotional behaviours and cortisol levels, given the varied effect across studies (Chen, Bell, & Deater-

Deckard, 2015), it is important to consider additional processes that may be influencing this association. Parenting has been examined as a mediator (Apter-Levi et al., 2016; Dubois-Comtois et al., 2013) given that greater maternal emotional stress has been linked to disrupted parent-child interactions (i.e. low sensitivity, intrusiveness ineffective discipline) (Huang, Caughy, Lee, Miller, & Genevro, 2009; Kim et al., 2011; Murray, Halligan, Goodyer, & Herbert, 2010) which has implications for offspring socioemotional behaviour problems (Leinonen, Solantaus, & Punama, 2003) and stress physiology (Blair et al., 2008; Kopp, 2009). Although parenting is one of the penultimate proximal factors influencing child development, given the impact of a child's immediate built environment on their developmental capacities (Dunn, 2012; Oliver, Dunn, Kohen, & Hertzman, 2007), consideration of alternative contextual factors, such as household chaos, is warranted. Household chaos is characterized by two primary dimensions: disorganization – referring to clutter, ambient noise, crowding and lack of structure; and instability - referring to frequent changes in residence, residents and routines (Brooks-Gunn et al., 2010; Wachs & Evans, 2010). Given its widespread associations with parent and child outcomes (Corapci & Wachs, 2002; Doom et al., 2018; Zilanawala et al., 2019), the current study aims to examine the indirect effect of maternal distress on child socioemotional behaviour and stress physiology via household chaos.

Maternal Distress and Household Chaos

Parents play an important role in structuring various aspects of the home environment. Parents can organize the state of the home (e.g. managing level of clutter and ambient noise), as well as establish stability via implementing consistent relationships, rules, routines and activities. Despite this anecdotal evidence, few studies have examined the influence of maternal elements of distress on their ability to manage the structure and activities within the home. Higher levels

of maternal depression have been associated with increased household chaos (Deater-Deckard et al., 2009; Pike, Iervolino, Eley, Price, & Plomin, 2006), however, to our knowledge, only one study to date has formally examined household chaos as a mediator between parental depression and child outcomes. Parents who reported higher depression levels, also described greater chaos in their home, which was associated with more problem behaviours in pre-school aged children (Hur et al., 2015). In the current study, we similarly argue that a mothers' capacity influences the dynamic of the home environment (i.e. setting routines and organizing schedules), and that this impacts child developmental outcomes. Maternal capacity, however, can be determined by various factors. For example, depressed mothers may face more daily stress (Field et al., 2006) which can hinder their ability to manage the home. The current study considers the constellation of these factors as a single composite of maternal distress including measures of depression, negative affect and stress and controlling for maternal executive functioning and parenting. We postulate that mothers who experience high levels of maternal distress may have challenges in maintaining order and predictability within the home and children exposed to this contextual risk are more likely to exhibit problem behaviours and dysregulation of their stress physiology.

Household Chaos, Socioemotional Functioning and Stress Physiology

There is increasing evidence of the impact of chaotic homes on child outcomes including socioemotional behaviours (Evans et al., 2005) and stress physiology (Brown et al., 2019). Higher levels of household chaos has been significantly associated with greater conduct problems (i.e. oppositional-defiant disorder, inattention, hyper-impulsivity, and externalizing behaviour problems) in kindergarten and first grade children beyond other environmental factors (e.g. literacy environment; Deater-Deckard et al., 2009). Similarly, in a sample of children aged four to eight years, chaotic homes were significantly associated with greater problem behaviour

above and beyond parental reports of positivity and/or negativity within the parent-child relationship (Coldwell et al., 2006). Further, ambient noise (an element of disorganization) was found to be positively associated with levels of aggression and attention problems in school-aged children (Martin et al., 2012). These findings are aligned with a plethora of literature illustrating the impact of household chaos on externalizing and internalizing behaviour problems in children (Bobbitt & Gershoff, 2016; Dumas et al., 2005) and adolescents (Deater-Deckard et al., 2019; Evans, Gonnella, Marcynyszyn, Gentile, & Salpekar, 2005).

Household chaos has also been associated with child stress physiology, although the effect on cortisol levels vary. For example, in a sample of low-income children aged seven to eight years, greater levels of household chaos was linked to a blunted diurnal cortisol slope (measured by saliva samples; Doom et al., 2018). Mild, but chronic exposure to chaos may upregulate cortisol levels throughout the day and prevent the natural decline of diurnal levels by the evening. Over time, however, this can lead to dysregulation of the HPA axis activity possibly accounting for the blunting effects (Miller et al., 2007). Lower diurnal cortisol output has also been shown in a sample of low income preschool children exposed to chaotic homes (Lumeng et al., 2014). In contrast to these findings, other studies have demonstrated elevated cortisol levels with exposure to household chaos (Brown et al., 2019; Chen, Cohen, & Miller, 2010; Laurent et al., 2014). Further, elevated morning basal cortisol levels were found in toddlers that experienced greater exposure to instability in their home (e.g. caregiver structure changes, residential mobility, job/income loss, familial death) than those that did not (Sturge-Apple, Davies, Cicchetti, Hentges, & Coe, 2017). Although findings are equivocal, collectively these studies demonstrate that household chaos is associated with dysregulation of the HPA axis – further

exploration of the nature of this association, with chronic measures of stress (hair cortisol) is warranted.

The Current Study

This study provides a novel examination of the impact of maternal distress on child functioning via its influence on household chaos. The aim of the current study was to: 1) examine direct effects of maternal distress on child hair cortisol levels and externalizing and internalizing behaviour problems; 2) investigate indirect effects of maternal distress on child hair cortisol levels and externalizing and internalizing behaviour problems via household chaos; and 3) explore potential differences in the indirect effect of maternal distress on child outcomes via modelling the two dimensions of household chaos separately – disorganization versus instability.

Methods

Sample

The study occurred from June 2016 to August 2018 and included a sample of 137 children and their mothers. Most participants (n = 91) were a part of a larger longitudinal study. Study inclusion included: 1) mothers were 18 years or older at time of birth; 2) mothers gave birth to full term, healthy infant; 3) mothers were able to access their children at the time of the home visits; and 4) mothers were able to read, write and speak English language. Exclusion criteria included any barriers to completion of research measures (e.g. severe disability, language barriers). Additional participants (n =46) were recruited from a database of families as a part of the Department of Psychology, Neurosciences and Behaviour at McMaster University. Prior consent had been provided by families to be contacted for research purposes. Eligibility criteria for the participants of the new sub-sample matched that of the participants recruited from the larger longitudinal study. At the point of recruitment for the new sub-sample, eligible

participants were mothers and their children between the ages of 4 years 11 months and 5 years 8 months old. Families were contacted over the telephone using a pre-approved script. Those who provided verbal consent over the telephone were scheduled for a home visit during which written, informed consent was obtained for all participants. Study protocol was approved by the McMaster Research Ethics Board and the St. Joseph's Healthcare Hamilton Research Ethics Board.

The final sample consisted of 125 participants (43 participants were from the sub-sample); at total of 12 mother-child dyads were excluded due to the following reasons: children with severe developmental delay (n = 2) and insufficient child measures completed (n = 10). The mean age of the children was 61.9 (SD = 2.0) months, with 49% females. Race composition consisted of 83.5% White, 2.4% Black, 2.4% Asian, and 11.7% Other (included those who reported more than one race). The majority of the mothers were married or in common-law relationships (88.5%). Approximately 32.6% of mothers had university level training, 27.7% had a college education and 26.9% had post-graduate training. The remaining 9.2% had a high school diploma or less. The median household income range was $105,000-133,499 CAD.

Procedure

Home visits were conducted with mother-child dyads by two female research assistants. The visits were approximately 2 hours in duration. Mothers completed a questionnaire package assessing their mood, stressful experiences, the home environment and their child's socioemotional functioning. The visit also included a home video tour conducted by mothers, videotaped mother-child interactions, and behavioural assessments of executive function completed by the mother. Hair samples were also collected from both mother and child

following established protocol. Participants were compensated for their time with $20 CAD and the children were given a toy.

Measures

Maternal Distress

Depression. Mothers completed the 20-item Center for Epidemiologic Studies-Depression Scale (CES-D; Radloff, 1997) as a measure assessing depressive symptomology experienced over the previous week. Higher scores indicate higher levels of depressive symptomology with a clinical cut-off score of 16. The CES-D has demonstrated high internal consistency and test-re-test reliability as well as adequate internal, concurrent and predictive validity with clinical ratings of depression and related self-report measures (Radloff, 1997). The measure for the present sample demonstrated good internal consistency (Cronbach's α = .89).

Hair Cortisol. During the home visit, research assistants collected hair samples from both mother and child (only hair cortisol values from the mother were included in the maternal distress composite and child hair cortisol values were used as an outcome). Approximately 50 to 60 strands of hair (15 to 20 strands for shorter hair) were cut with scissors as close to the scalp as possible from multiple sections along the posterior vertex of the head. Samples were paper clipped to cardstock (with an arrow indicating the root) and placed into a sealed Ziplock bag. Collected samples were stored in a dry, dark locked storage drawer prior to analysis. A standardized questionnaire was administered to mothers regarding factors that could affect hair cortisol levels as per the literature including: current medications, chemical treatments, household smoke exposure, and ethnicity (Dettenborn, Tietze, Kirschbaum, & Stalder, 2012; Gray et al., 2018; Smy et al., 2015).

Using pre-established protocol (Vaghri et al., 2013), 3 cm of hair (most proximal to scalp) from each sample was placed into a Falcon 50 mL conical centrifuge tube. Isopropanol (12mL) was used to wash the hair twice. The tube was shaken for 2 minutes by hand and the isopropanol was discarded. To allow for complete evaporation of the isopropanol, tubes were left open to air dry for approximately 48 hours. Once dry, hair samples were pulverized in a grinding jar using four stainless steel ball bearings in the Retsch CryoMill at 25 Hz for 3 minutes. The ground hair powder (approx. 30-35mg) was transferred to a 2 mL Eppendorf tube where 1 mL of 100% ethanol was added (as an less toxic and abrasive option compared to methanol used in (Vaghri et al., 2013). The tube was shaken by hand and subsequently rotated at 45 rpm on the RPI Mix-All Laboratory Tube Mixer for 24-72 hours at room temperature. Samples were then vortexed for 5 seconds and centrifuged at 2800 rpm for 15 minutes. New 2mL Eppendorf tubes (supernatant tube) were used to house 0.8 mL of the aliquoted supernatant. The tubes were left open to allow evaporation of ethanol over 48-hour period. Adding another 1mL of 100% ethanol, the tubes went through another cycle of rotation at 45 rpm on the RPI Mix-All Laboratory Tube Mixer for 24-72 hours at room temperature and then vortexed for 5 seconds and centrifuged at 2800 rpm for 15 minutes. Final extraction of 1 mL of supernatant into the supernatant tubes followed, and the tubes were left to air dry for 48 hours. Using 150uL of Salimetrics Salivary Cortisol Assay Diluent, the supernatant was regenerated, vortexed for 5 seconds and centrifuged for 10 minutes. Samples were assayed in duplicate high-sensitivity enzyme-linked immunosorbent assays using the High Sensitivity Salivary Cortisol Immunoassay Kit (Cat# 1-3002, Salimetrics, Pennsylvania), as per the manufacturer's instructions.

Negative Affect. Using pre-established methodology (Saxbe & Repetti, 2010), mothers conducted videotaped tours of their home following a prompt instructing them to emphasize

meaningful home spaces and possessions (e.g. describe spaces and possessions which are most important to your family) during the tour. The research assistant did not accompany the mother on this tour. Tours ranged from 1 minute, 4 seconds to 14 minutes, 51 seconds. Two independent researchers transcribed the videos verbatim and 20% were checked by a third research assistant. Most of the videos were continuous, however, there were few instances where videos were stopped and then resumed shortly after. Only the mother's dialogue was transcribed. Where mothers engaged in extensive dialogue (i.e. beyond 2 lines of text) with other family members during the tour, the responses beyond the first reply were removed. Transcripts of the home tours were analyzed using a Linguistic Inquiry and Word Count (LIWC) software. LIWC uses criteria of specified categories in order to generate word frequency counts. The pre-set 'negative affect' category was used. The negative affect category includes words related to anger, sadness, fear and anxiety. Examples of words included are shown in Table 2. Overall frequency counts for negative affect were included in the analysis.

Household chaos

CHAOS Scale. Mothers reported levels of household chaos with the 15-item Confusion, Hubbub, and Order Scale (CHAOS; Matheny, Wachs, Ludwig, & Phillips, 1995). Mothers rated their homes based on a four-point scale (*1 = very much like your own home, 4 = not at all like your own home*). Items included "We can usually find things when we need them", and "Our home is good place to relax." Higher scores indicate greater chaos in the home. The scale has demonstrated good test-retest reliability over a 12-month period (r = .74) and in the present sample, high reliability (Cronbach's α =.85).

Narrated Home Video Tours. Transcripts of the home tours were analyzed using the LIWC software. For household chaos, a custom dictionary was created to generate a list of

relevant words and phrases following the pre-established protocol of LIWC developers (Pennebaker, Chung, Ireland, Gonzales, & Booth, 2007). The final custom dictionary entered into LIWC was developed from: 1) reviewing and extracting chaos-related terms from the CHAOS scale, extant household chaos literature and a sub-set of the transcripts; 2) two trainees (KA, AT) systematically developing a codebook based on the extracted terms; 3) entering all transcripts into NVivo 12 Plus qualitative data analysis software (QSR International, 2018) where the study's first author reviewed and categorized relevant words and phrases. The final lists were reviewed and rated systematically by two independent trainees (KA, SK) to create the final custom dictionary (see Table 2 for included words). The dictionary and transcripts were entered into the LIWC software, from which final word frequencies for the household chaos categories were obtained.

Family inventory of life events and changes (FILE). The Family Inventory of Life Events and Changes (FILE) 9-item questionnaire assesses the family's experience of a variety of life changes (McCubbin et al., 1983). Mothers indicated whether they had experienced each event in the past month, past year, lifetime, never or prefer not to answer. One item pertaining to changes in relationship status (e.g. divorce, separation, remarriage, new partner) within the past year was used due to its statistical and theoretical relevance to household chaos.

Residential Mobility. Mothers reported the number of times their child had moved from one residence to another in the past 5 years as a part of a larger demographic questionnaire.

Child Behavioural Problems

Mothers completed the 99-item Child Behaviour Checklist (CBCL) (Achenbach & Ruffle, 2000) for pre-school children aged 1.5 to 5 years describing common childhood problems that divide into subscales: externalizing and internalizing behaviours problems. Mothers rated

each problem statement on a three-point rating scale (*0 = not at all, 1= sometimes, 2 = often*). The internalizing scale includes four subscales: emotionally reactive, anxious depressed, withdrawn, and aggressive behaviours. The externalizing scale includes two subscales: attention problems and aggressive behaviours. Previous studies report good reliability and validity of the instrument (Achenbach & Ruffle, 2000). In the current study, the CBCL also demonstrates good internal consistency for internalizing (Cronbach's $\alpha = .86$) and externalizing (Cronbach's $\alpha = .92$) scales.

Maternal Executive Functioning

Mothers completed the Flanker Inhibitory Control and Attention Test (Flanker) and the Dimensional Change Card Sort (DCCS) from the National Institute of Health (NIH) toolbox: Cognition Battery (Weintraub et al., 2013; Zelazo et al., 2013) in assessing executive functions. Tasks were completed on an iPad provided by the research assistants. The NIH toolbox is a computerized battery of measures that can be administered to participants aged 3 to 85.

Inhibitory Control and Attention. The Flanker task assesses mother's ability to attend to single visual stimulus and ignore distractor stimuli. The research assistant read the instructions on the screen to the mother to attend to the middle arrow (visual stimulus) and choose the button that matches the direction that it is pointing. Two types of trials were presented to the mother – in the congruent trial, the middle arrow faced the same direction as the other arrows in the row and in the incongruent trial, the middle arrow faced the opposite direction of the other arrows. The mother was given up to three practice rounds with four trials within each. The test trials consisted of 20 items with arrow stimuli. Scoring was based on both accuracy and reaction time. If the accuracy levels were below 80%, the computed score was equivalent to the accuracy score. However, when at or greater than 80%, the reaction time was combined with the accuracy score.

The scores were adjusted for age based on a normative sample (Slotkin et al., 2012). Higher scores indicate better inhibitory control and attention. Reliability and validity was excellent for this measure (Weintraub et al., 2013).

Cognitive Flexibility. Mothers completed the DCCS that consisted of two blocks: practice and mixed. In the practice block, mothers were instructed (via instructions on the screen read by the research assistant) that they were going to sort stimuli by dimension (i.e. shape or colour). The mother was shown a visual stimulus (e.g. brown rabbit) and instructed to match the stimulus by shape to one of the two other stimuli (e.g. brown rabbit, white boat) presented below it. Mothers who got at least 3 out of 4 correct moved onto the next practice round. Those that did not were given up to three rounds of practice (each with four trials). In the second practice round, mothers had to match the presented visual stimulus (e.g. white boat) to one of the two other stimuli (e.g. white rabbit, brown boat) shown below it by colour. Mothers were directed to the middle of the screen via a visual cue (i.e. star) throughout the task. The Mixed block comprised the test trials where the stimuli were changed to trucks and balls that were yellow and blue. Mothers had to match the presented visual stimulus by shape or colour to one of two other visual stimuli presented below it. There were 30 test items and the dimensions alternated. The same scoring methods were used for DCCS as described for the Flanker test. Higher scores indicate better cognitive flexibility. Task reliability and validity was excellent (Weintraub et al., 2013).

Parenting

Structured Etch-A-Sketch Task. Mother-child dyads were videotaped as they participated in a structured interaction task - the Etch-a-Sketch task (Stevenson-Hinde & Shouldice, 1995). Mothers and children were each assigned a knob and were not allowed to touch or manipulate the other's knob. They were given a practice trial which depicted two

stacked rectangles (of differing widths) that they had to draw. For the test trial, they were provided a more complex picture (i.e. a house). There was no set time for completion. Parenting was coded for cognitive sensitivity (Prime et al., 2015) and emotional availability (EAS; Biringen, 2008). Cognitive sensitivity includes indices for mindreading, communicative clarity, and mutuality building behaviours (Prime et al., 2015). Three independent coders were trained to reliability (Cronbach's $\alpha > .80$) by an expert coder (developer of cognitive sensitivity scale) and coded the remaining videos independently. Coders used a 5-point Likert scale for each of the 11 items with responses ranging from 'Not at all true' (1) to 'Very true' (5). A mean of the 11 items was calculated and used as the final score with higher scores indicating higher cognitive sensitivity. Double coding was conducted with a random selection of videos and inter-coder reliability was good (Cronbach's $\alpha = .80$). Where there were any discrepancies in codes, the scores of the expert coder was used as the final score. Emotional availability was measured using the 4th edition of the Emotional Availability Scales (EAS; Biringen, 2008). A trained and certified EAS coder scored the parent-child interaction videos (as a primary coder) using four parent scales – sensitivity, structuring, non-intrusiveness, and non-hostility – from 1 to 7. A second trained and certified EAS coder reviewed a subset of 20 videos and reliability between coders was excellent (ICC = .81). Sum scores of the four scales for each dyad were made where higher scores indicate higher emotional availability.

Statistical Analyses

Descriptives and bivariate correlations were examined for all study variables and are reported in Table 1. All analyses were conducted using Mplus 8.3 (Muthén & Muthén, 1998-2017). Outcome variables were log transformed (i.e. externalizing behaviour problems) and winsorized (i.e. hair cortisol) prior to analyses (if needed) to correct for non-normal distributions

where an outlier beyond three standard deviations existed. Three composite variables were included in the analysis, maternal distress, household chaos and parenting. The maternal distress composite was constructed, using principal component analysis, with the Z scores (with mean zero and standard deviation one) of the CES-D total score, the word frequency count from the LIWC software referencing negative affect and maternal hair cortisol values. Component weights varied from .49 to .71 and were combined to create a linear regression-weighted composite. For the household chaos and parenting composites, variables were transformed into Z scores (with mean zero and standard deviation one) and summed following the recommendation of simple averaging (Song, Lin, Ward, & Fine, 2013). The conversion of Z scores permits equal contribution of each variable to the composite via preserving the distribution of the scores of each included variable. The household chaos composite included multiple variables to account for its two dimensions: disorganization and instability. For the disorganization dimension, we included the total score for the CHAOS Scale and the word frequency count from the LIWC software referencing clutter, ambient noise and lack of structure in the home from the transcripts. These two measures were combined to create a 'disorganization' composite. For the instability dimension, we included the FILE item (i.e. changes in relationship status in past year), the residential mobility variable (i.e. number of moves in the past 5 years) and the word frequency count from the LIWC software referencing caregiver changes, residential changes, frequent visitors in and out of home and unpredictable routines from the transcripts. These measures were combined to create an 'instability' composite. Both the 'disorganization' and 'instability' variables were combined into a composite to represent a 'household chaos' construct. The parenting composite included total scores for cognitive sensitivity and emotional availability which were positively and significantly correlated (r = .57).

Structural equation modeling was used to assess three models: direct and indirect effects (via household chaos) of maternal distress on child hair cortisol levels (Model 1), externalizing behaviour problems (Model 2) and internalizing behaviour problems (Model 3). Specifically, the total effect between maternal distress and each of the child outcomes (without household chaos) and the direct effect between maternal distress (with household chaos) and each of the child outcomes were examined. Examination of the indirect effects (i.e. effect of maternal distress on child hair cortisol, externalizing and internalizing behaviour problems through household chaos) followed the recommendation of using bias-corrected bootstrap confidence intervals (CIs) which accounts for non-normality of estimates and provides the greatest statistical power (Fritz & MacKinnon, 2007; MacKinnon et al., 2004). This is established via drawing resamples with replacement from the observed dataset (5,000 draws in the current study) and then estimating the indirect effect for each sample which are used to generate bias-corrected confidence intervals. This method is recommended for indirect effect models with small to moderate sample sizes (Shrout & Bolger, 2002). A bias-corrected confidence interval that does not include zero indicates the indirect effect is statistically significant. Standardized estimates were reported. Covariates included were selected based on theoretical considerations and model parsimony: household income (combined maternal and paternal salaries), sex of child (coded as 1 = male, 0 = female), parenting (composite of cognitive sensitivity and emotional availability) and maternal executive functioning (NIH Toolbox Flanker and DCCS). A series of secondary analyses were also conducted to examine the possible differential effects of maternal distress on each dimension of household chaos for each child outcome. Model 4a involved the association between maternal distress and child hair cortisol both directly and indirectly via household disorganization; and Model 4b involved the association between maternal distress and child hair

cortisol both directly and indirectly via household instability. Models 5a-b and 6a-b followed the same paths from maternal distress to disorganization and instability for each of externalizing and internalizing behaviour problems separately. Structural models were assessed using the following indices of model fit: the likelihood ratio chi-square test, comparative fit index (CFI) and root mean squared error of approximation (RMSEA). As per standard recommendations, a non-significant chi-square test, as well as values greater than .95 for CFI and less than .05 for RMSEA are considered indicative of good model fit (Hu & Bentler, 1999).

Missing Data

Missing data ranged from 0.8 – 9.8% for main study variables. Full Information Maximum Likelihood Estimation (FIML) (Muthén & Muthén, 2017) within the structural equation modeling framework was used to account for missing data and non-normal distribution. This approach is considered to be superior to other traditional methods (i.e. listwise deletion, pairwise deletion, multiple imputation; Enders & Bandalos, 2001) as it retains statistical power and produces unbiased estimates.

Results

Descriptive Statistics

Means and standard deviations for main study variables and covariates as well as bivariate correlations are presented in Table 1. Moderate, positive associations were found between child externalizing and internalizing behaviour problems, however, neither were correlated with child hair cortisol levels. Child hair cortisol, externalizing and internalizing behaviour problems were positively associated with maternal distress. Further both externalizing and internalizing behaviour problems and maternal distress were positively associated with the household chaos composite and household disorganization, but not household instability.

Table 1. Means, standard deviations and bivariate correlations for main study variables and covariates.

Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10	11
1. Child hair cortisol levels	11.63	17.82	1	-.18	.05	.31**	-.05	-.13	-.01	-.05	-.11	-.12	-.03
2. Externalizing behaviours	43.95	9.12	-.18	1	.51**	.30**	.44**	.47**	.07	-.25**	-.10	-.13	-.07
3.Internalizing behaviours	47.17	9.90	.05	.51**	1	.36**	.31**	.33**	.06	-.10	-.12	-.23**	-.14
4.Maternal distress	0	1	.31**	.30**	.36**	1	.42**	.37**	.08	-.20*	-.08	-.33**	-.07
5.Household chaos	0	.69	-.05	.44**	.31**	.42**	1	.74**	.5**	-.20*	-.05	-.17	-.02
6.Household disorganization	.01	.77	-.13	.47**	.33**	.37**	.74**	1	-.09	-.12	-.07	-.03	-.07
7.Household instability	0	.72	-.01	.07	.06	.08	.5**	-.09	1	-.09	-.03	-.08	.08
8. Parenting	0	.89	-.05	-.25**	-.10	-.20*	-.20*	-.12	-.09	1	.11	.14	.06
9. Maternal executive functions	0	.88	-.11	-.10	-.12	-.08	-.05	-.07	-.03	.11	1	.07	.10
10. Household income (median, CAD)	$105,000 – 133.499		-.12	-.13	-.23**	-.33**	-.17	-.03	-.08	.14	.07	1	-.12
11. Sex of the Child (% female)	49		-.03	-.07	-.14	-.07	-.02	-.07	-.08	.06	.10	-.12	1

* $p < .05$, ** $p < .01$

Descriptive statistics for the video home tours are shown in Table 2. Word counts generated by LIWC represent the number of words in a category as a percentage of the total number of words in a transcript. Each word in the dictionary was used at least once in two distinct home tours. The mean base rate was 26% meaning that approximately 33 of 128 tours included words from both disorganization and instability categories. The disorganization category was more frequently discussed in home tours with the most widely used words related to clutter (75 tours). The base rate for negative affect was approximately 70% with words related to sadness (45 tours) followed by anger (23 tours).

Table 2. Percentage of words in home tour custom categories for household chaos construct and pre-set category for negative affect.

Category	Disorganization	Instability	Negative Affect
Words included	chao*; clutter*; disarray; disast*; disorganiz*; hoard*; mess*; nois*; reno*; unclean; unfinished; untidy	attempt; entertaining; guests; new residence; novel; separation; visit*	alone; bother*; fight*; sadly; scare/scary; sorry; stress*
Min to max	0 to 2.41	0 to 1.92	0 to 3.61
Mean	.35	.15	.45
Median	.25	0	.33
Standard deviation	.43	.30	.50

Maternal Distress, Household Chaos and Child Hair Cortisol Levels

The structural equation model (Model 1) examining the direct and indirect effect of maternal distress on child hair cortisol levels via household chaos demonstrated excellent model fit: (n = 125, χ^2 (5) = 1.77, p = .88; RMSEA = .00; CFI = 1.00). Standardized coefficients of all paths are presented in Table 3. A significant total effect (path c) of maternal distress to child cortisol levels (without household chaos) was found (β = .26, 95% CI [.08, .44]). Greater maternal distress was associated with higher levels of household chaos (path a) and higher levels of household chaos was associated with lower levels of hair cortisol (path b). There was a significant indirect effect from maternal distress to child hair cortisol levels via household chaos (path ab). The direct effect of maternal distress on child hair cortisol levels remained significant with the addition of household chaos (path c'). Overall the model explained 14% of the variance in hair cortisol levels. No covariates emerged as significant.

Table 3. Structural model parameter estimates for maternal distress, household chaos, and child hair cortisol levels (Model 1).

Model 1	Standardized Coefficient	95% CI
Maternal distress → child cortisol levels (path c')	**.36**	**[.16, .54]**
Maternal distress → household chaos (path a)	**.46**	**[.31, .58]**
Household chaos → child cortisol levels (path b)	**-.23**	**[-.39, -.03]**
Maternal distress → household chaos → child cortisol levels (path ab)	**-.11**	**[-.19, -.02]**

Note: bolded effects are significant

Maternal Distress, Household Chaos and Behaviour Problems

The structural equation models examining the direct and indirect effect of maternal distress on child externalizing (Model 2) and internalizing (Model 3) behaviour problems via household chaos demonstrated excellent model fit: (n = 125, χ^2 (5) = 1.77, p = .88; RMSEA = .00; CFI = 1.00). Standardized coefficients of all paths are presented in Tables 4 and 5. A significant total effect of maternal distress to child behaviour problems (without household chaos) was found for externalizing (path c; β = .25, 95% CI [.80, .42]) and internalizing behaviours (path c; β = .27, 95% CI [.11, .29]). Greater maternal distress was associated with higher levels of household chaos (path a) and higher levels of household chaos was associated with greater externalizing and internalizing behaviour problems (path b). There was a significant indirect effect from maternal distress to externalizing and internalizing behaviour problems via household chaos (path ab). With the addition of household chaos, the direct effect of maternal distress on child externalizing and internalizing (path c') did not remain significant. Overall the model explained 25% of variance for externalizing behaviour and 20% for internalizing behaviour problems. No covariates emerged as significant.

Table 4. Structural model parameter estimates for maternal distress, household chaos, and child externalizing behaviour problems (Model 2).

Model 2	Standardized Coefficient	95% CI
Maternal distress → child externalizing behaviours (path c')	.08	[-.15, .30]
Maternal distress → household chaos (path a)	**.46**	**[.31, .58]**
Household chaos → child externalizing behaviours (path b)	**.39**	**[.20, .56]**
Maternal distress → household chaos → child externalizing behaviours (path ab)	**.18**	**[.10, .29]**

Note: bolded effects are significant

Table 5. Structural model parameter estimates for maternal distress, household chaos, and child internalizing behaviour problems (Model 3).

Model 3	Standardized Coefficient	95% CI
Maternal distress → child internalizing behaviours (path c')	.17	[-.06, .39]
Maternal distress → household chaos (path a)	**.46**	**[.31, .58]**
Household chaos → child internalizing behaviours (path b)	**.26**	**[.06, .43]**
Maternal distress → household chaos → child internalizing behaviours (path ab)	**.12**	**[.03, .21]**

Note: bolded effects are significant

Household Disorganization and Child Hair Cortisol Levels, and Externalizing and Internalizing Behaviour Problems

The role of household disorganization in the structural equation model was examined via a series of secondary analyses. For all three outcomes, greater maternal distress was significantly associated with higher levels of household disorganization (path a; β = .54, 95% CI [.3, .71]) and higher levels of household disorganization was significantly associated with lower levels of hair cortisol (Model 4a: path b; β = -.33, 95% CI [-.52, -.14]) and greater externalizing (Model 5a: path b; β = .47, 95% CI [.28, .61]) and internalizing (Model 6a: path b; β = .27, 95% CI [.05, .45]) behaviour problems. Significant indirect effects of maternal distress to child hair cortisol

levels (path ab; β = -.18, 95% CI [-.34, -.07]), externalizing (path ab; β = .25, 95% CI [.13, .41]) and internalizing (path ab; β = .15, 95% CI [.04, .29]) behaviour problems via household disorganization were found. The direct effect of maternal distress on child hair cortisol levels remained significant with the addition of household disorganization (path c'; β = .44, 95% CI [.23, .64]). However, for externalizing (path c'; β = -.02, 95% CI [-.27, .21]) and internalizing (path c'; β = .13, 95% CI [-.14, .36]) behaviour problems, the direct path from maternal distress did not remain significant with the addition of household disorganization. The models explained 18% of the variance in cortisol levels, 29% in externalizing behaviour problems, and 21% in internalizing behaviour problems. Model fit for the structural equation models was excellent (n = 125, χ^2 (5) = 2.73, p = .74; RMSEA = .00; CFI = 1.00). No covariates emerged as significant.

Household Instability and Child Hair Cortisol Levels, and Externalizing and Internalizing Behaviour Problems

The role of household instability in the structural equation model was examined via a series of secondary analyses. For all three outcomes, maternal distress was not significantly associated with household instability (path a; β = .12, 95% CI [-.06, .33]); nor was household instability significantly associated with levels of hair cortisol (Model 4b: path b; β = -.03, 95% CI [-.19, .14]), externalizing (Model 5b: path b; β = .11, 95% CI [-.07, .32]), or internalizing (Model 6b: path b; β = .10, 95% CI [-.07, .25]) behaviour problems. There was no significant indirect effect from maternal distress to child hair cortisol levels (path ab; β = -.003, 95% CI [-.05, .01]), externalizing (path ab; β = .01, 95% CI [-.01, .08]) and internalizing (path ab; β = .01, 95% CI [-.004, .07]) behaviour problems. The models explained 10% of the variance in cortisol levels, 14% in externalizing behaviour problems, and 16% in internalizing behaviour problems.

Model fit for the structural equation models was excellent (n = 125, χ^2 (5) = 4.95, p = .42; RMSEA = .00; CFI = 1.00). No covariates emerged as significant.

Discussion

The present study examined associations between maternal distress and child socioemotional behaviours and stress physiology, as well as the indirect effect via household chaos. The current study demonstrated a significant direct association between mothers experiencing higher levels of distress and high levels of hair cortisol in children. Indirect effects via household chaos were also significant, demonstrating that a higher level of maternal distress was linked to higher levels of household chaos, which was associated with lower levels of hair cortisol in children. Significant indirect effects were also found for externalizing and internalizing behaviour problems, with greater maternal distress positively associated with increased problem behaviours via higher levels of household chaos. Furthermore, household disorganization, and not instability, had a significant role in these indirect effect models. Insight into the mechanisms through which maternal distress can shape the home environment and thereby impact child development is important to inform interventions that may aid in equipping mothers with the support and tools needed to provide order and stability in the home to foster healthy child outcomes.

Direct Effects of Maternal Distress

The direct effect of maternal distress on child externalizing and internalizing behaviours did not remain significant once household chaos was accounted for. Conversely, significant direct associations were found between maternal distress and child hair cortisol levels with and without the inclusion of household chaos. This suggests that the HPA axis of children may be particularly sensitive to the effects of maternal mood and stress physiology which has been seen

in other studies (Apter-Levi et al., 2016; Ulmer-Yaniv et al., 2018). This association may be driven, in part, by the strong association (i.e. $r = .52$) between maternal and child cortisol levels. One study demonstrated that increased diurnal cortisol output in school-aged children was associated with stronger mother-child diurnal cortisol synchrony suggesting that children exhibiting greater physiological stress may be more vulnerable to the influences of maternal stress physiology (Pratt et al., 2017). Also, it is important to consider that the current sample of children are still undergoing rapid neural development which makes systems such as the HPA axis vulnerable to environmental risks (Gunnar & Quevedo, 2007). For problem behaviours, the direct association did not remain significant when household chaos was included in the model. This may suggest that the effects of maternal distress at this stage are too subtle to override the stronger influence of the structure and activities within the home environment. Replication studies with larger, diverse samples are needed to further investigate.

Indirect Effects of Maternal Distress via Household Chaos

Significant indirect effects were found for child hair cortisol levels and externalizing and internalizing behaviour problems, specifically with household disorganization. The findings suggest that mothers experiencing greater distress, may have more difficulty organizing and maintaining order in the home, and this is associated with lower levels of cortisol as well as heightened externalizing and internalizing behaviour problems. Although not overtly threatening, chronic exposure to disorder in the home likely poses as a mild stressor throughout each day (Doom et al., 2018). Over time, and in addition to the effects of maternal distress, the repeated exposure to these stressors may be perceived as uncontrollable in younger children and therefore may impact the functioning of the HPA axis (Wachs & Evans, 2010). Indeed, the threat of multiple stressors acting in concert may account for attenuation of the HPA axis with blunted

diurnal salivary cortisol levels in school-aged children (Doom et al., 2018). Similar findings are seen in school-aged children of mothers with depressive symptoms and who are concurrently exposed to other risks (e.g. financial strain; Badanes, Watamura, & Hankin, 2011). Similarly, a child regularly exposed to a disordered home (e.g. clutter, structural deficiencies and ambient noise) may have difficulty regulating their emotion and behaviour (Evans et al., 2005) towards coping with the effects. Difficulties in adjusting can translate to maladaptive coping mechanisms and/or increased anxiety or social withdrawal accounting for the heighted externalizing and internalizing behaviours.

Interestingly, in the current study, the inclusion of instability in the indirect effects model for all three child outcomes did not emerge as significant. Other studies have previously demonstrated stronger effects of disorganization than instability on child diurnal cortisol levels (Blair et al., 2013) and emotional and behavioural problems (Coley, Leventhal, Lynch, & Kull, 2013; Coley, Lynch, & Kull, 2015). This may be due to the difference in the chronicity of the two dimensions of household chaos; instability is likely a more acute stressor, whereas disorganization is more chronic. Some studies have shown that even a few instances of instability can negatively impact cognitive and behavioural development (Fomby & Cherlin, 2007; Tiesler et al., 2013). However, in the present study, risk of instability was fairly low (i.e. 92% did not experience change in caregivers in past year; 54% had not experienced residential move in past five years). As such, it may be that the low risk and low frequency of these occurrences may not be potent enough to impact child socioemotional functioning and stress physiology.

Strengths and Limitations

The current study addresses an important gap in the literature by examining an environmental pathway through which mothers may affect child socioemotional behaviours and stress physiology. Our novel, multi-method approach (i.e. self-report, home tours, video-taped interactions, hair cortisol) provides some objectivity in interpreting the findings. For example, the inclusion of hair cortisol provides a reliable biomarker of chronic stress in children who are exposed to maternal distress and household chaos. To date, the majority of studies either rely on report measures of stress or other transient measures of cortisol (e.g. saliva). Additionally, the findings from this study showed that the indirect effects of maternal distress on child socioemotional behaviours and stress physiology occurred beyond the effects of parenting and maternal executive functioning – two factors that have previously been suggested to play a role in this mechanism. This suggests that children may be particularly sensitive to the structure and dynamics of the home environment.

Despite these strengths, there are some limitations that should also be considered. First, the cross-sectional design prevents assessment of the effects of maternal distress and household chaos over time. Both maternal distress (Crnic et al., 2005; Yoo et al., 2014) and household chaos (Deater-Deckard et al., 2009; Hart, Petrill, Deckard, & Thompson, 2007), have shown consistency over time; as such a longitudinal design would better permit evaluation of the effects of these proximal processes on child development. Further, it would provide greater insight into the directionality of effect given possible reciprocal associations between maternal distress, household chaos and child outcomes. Second, fathers or other caregivers within the home that may affect the child outcomes of interest were not evaluated in the present study. This is an important consideration given the dearth of studies assessing the influence of fathers, despite

findings that their levels of psychological distress can also significantly increase the risk of preschool children exhibiting externalizing and internalizing behaviour problems above and beyond maternal mental health, parenting and other related family variables (Gulenc, Butler, Sarkadi, & Hiscock, 2018). Third, while our construct of maternal distress is novel with the inclusion of hair cortisol, future studies should consider evaluations of interpersonal relationships (e.g. relationship quality, presence of additional social supports), as well to obtain a more ecological perspective of the overall functioning of mothers. Fourth, the current study relied only on one informant of child behaviour problems. While some have argued that mothers who experience high levels of distress may over-report problem behaviours in their children (Boyle & Pickles, 1997), it is possible that the current study's inclusion of hair cortisol combats possible shared method variance between maternal distress and child behaviour problems. This is further supported by the fact that with the introduction of an environmental pathway between maternal distress and child behaviour problems, the direct association didn't remain significant which would not be expected if associations were inflated. With that said, the addition of another informant that can provide a perspective of the child's behaviour is a different setting (i.e. school) would make for more robust findings.

Conclusion

The present study uses novel, multi-method approaches to demonstrate that household chaos plays an important role in the association between maternal distress and child outcomes. In particular, household disorganization appears to exacerbate the effects of maternal distress which can lead to dysregulation of children's stress response and elevate problem behaviours. These findings are important to develop and evaluate interventions aimed at supporting maternal

psychological and physical health and to foster order within the home to promote healthy developmental trajectories for children.

Chapter 5: General Discussion

5.1 Summary

Child outcomes are shaped by the proximal processes within the child's home environment. Contextual risk factors such as household chaos have the capacity to threaten these processes with adverse implications for multiple domains of child functioning. Taken together, these three studies demonstrate: 1) household chaos has a direct, negative impact on child executive functioning with significant moderating factors including measurement approach to executive functioning, household chaos dimension, proportion of minorities in the sample and parental educational training; 2) greater household chaos is indirectly associated with poor executive functioning via lower cognitive sensitivity and emotional availability; and 3) elevated maternal distress is directly associated with greater hair cortisol levels, but indirectly associated with lower levels of hair cortisol via greater levels of chaos in the home; additionally, maternal distress is also indirectly associated with elevated externalizing and internalizing behaviour problems via household chaos.

5.1.a. Study 1

Numerous studies have demonstrated the significant adverse effects of household chaos on child executive functioning. While the findings have been consistent, some variation exists and exploration of possible moderators influencing the association has been minimal. To the best of my knowledge, this is the first study to formally synthesize these findings via meta-analytic techniques as well as to systematically explore potential moderating factors. The meta-analysis demonstrated a small, but significant effect of household chaos on child executive functioning. These findings are comparable to a recent meta-analysis examining the association between socioeconomic status and executive functioning (r = .16) in children and adolescents (Lawson et

al., 2017). Moderator analyses demonstrated that the measurement approach of executive functioning modulated the association between household chaos and child executive functioning such that a stronger association was seen in studies that used questionnaires rather than direct assessment. Questionnaires are considered to provide an ecologically valid assessment of executive functioning; however, their limited discriminant validity, potential for recall inaccuracies, and shared method variance are all factors that indicate the need to cautiously interpret these findings. Further to this point, moderator analyses conducted within each measurement approach resulted in three additional moderators emerging for direct assessment, but no significant moderators were found for questionnaires. This suggests that direct assessment may provide a nuanced examination of the effect of household chaos on child executive functioning. Three of the significant moderators, household chaos dimension, racial/ethnic composition of the sample and parental education, all indicate the importance of environmental influences on child executive functioning. Instability, rather than disorganization, strengthened the association between household chaos and child executive functioning which is consistent with related studies (Cooper et al., 2011; Ziol-Guest & Mckenna, 2014). This suggests that exposure to unpredictable environments may interfere with developing executive functioning, which emerges in the child's inability to manage their affect and behaviours in such environments (Evans et al., 2005). Greater effects of household chaos on child executive function were also seen in samples with higher proportion of minorities. To the best of my knowledge, no studies have explicitly examined potential differences in the effect of household chaos on executive functioning based on race/ethnicity. This may indicate a greater vulnerability to the household chaos in minority children; however, it may also indicate inherent bias in administration of the tasks since it only emerged in direct assessment analyses. Finally, the

strength of association was greater in samples of parents with lower educational training which may be indicative of difficulties that these parents have in providing high cognitive stimulation in their home environments as well as consistent and high-quality interactions with their children (Deater-Deckard et al., 2009). These findings demonstrate the adverse impact of household chaos on child executive functioning and the exacerbating effects that instability and familial demographics have on this association. However, these findings should be considered in light of certain limitations. Certain potential moderators could not be examined due missing data and/or restricted data ranges (e.g. child verbal ability, income-to-needs ratio) presented in the study. Similarly, correlations between household chaos and executive functioning were missing in some studies prompting the need to conduct sensitivity analyses. Future researchers should prioritize the inclusion of all relevant data, both direct assessment and multi-informant questionnaires, for more robust analyses to be conducted. In addition, future research should focus on the mechanisms that underlie the effect of household chaos on children's executive functioning via longitudinal studies; including the ways in which instability and familial demographics may differentially destabilize executive functioning in children over time.

5.1.b. Study 2

Parenting has emerged as a plausible mediating factor between household chaos and child executive functioning, although has not formally been studied extensively. The findings from study 2 demonstrated that, in addition to the direct effect that household chaos has on child executive functioning, there was also an indirect effect found via maternal cognitive sensitivity and emotional availability. This suggests that greater levels of chaos in the home may interfere with a parent's ability to meaningfully interact with their child and they may default to more ineffective or harsh practices (Coldwell et al., 2006). As such, children not only experience the

direct stress of an uncontrolled environment, but also experience less support and guidance from their caregiver. Our findings of an indirect effect are consistent with only one other study to date formally examining this mechanism (Vernon-Feagans et al., 2016). In contrast to my study, however, Vernon-Feagans and colleagues used a cumulative measure of chaos from approximately 2 to 36 months (my study measured household chaos at approximately 5 years old only), and they found that only household disorganization indirectly predicted behavioural regulation (i.e. working memory, attention, inhibitory control) via parenting (i.e. maternal responsivity and acceptance) and early executive function skills (at three years old) (Vernon-Feagans et al., 2016). My study, however, found that instability had a more salient effect than disorganization on the child executive functioning, but also had a stronger association on parenting via the indirect mechanism. The difference may be due to the difference in age when instability was measured. For Vernon-Feagans and colleagues, transitions experienced prior to age three, may not have been as disruptive as disorganization in the home (Vernon-Feagans et al., 2016). Notably, our findings are aligned with the meta-analysis in Study 1 which identified instability as strengthening the association between household chaos and child executive functioning. Disruptive transitions (e.g. changes in residence, familial structure, employment or death or illness in family) may tax a parent's energy levels and mood (Forman & Davies, 2003) which can negatively affect their interactions with their child. Finally, sex-based analyses suggested that household chaos compromises a mother's cognitive sensitivity and emotional availability which disrupts the executive functioning of male children more so than female children. It may be that mothers who are already experiencing the stress of a chaotic home are harsher in their interactions with their male children. Alternatively, it is possible that male children are more sensitive to environmental threats. Overall, the research on sex differences is

mixed (Cabrera et al., 2017; Cooper et al., 2011; Endendijk et al., 2016; Jocson & Mcloyd, 2015) and warrants further investigation.

5.1.c. Study 3

Maternal distress has been shown to adversely impact child socioemotional behaviours (Yoo et al., 2014) and stress physiology (Apter-Levi et al., 2016). Previous research has suggested that the mechanism through which this occurs may be via parenting practices. However, consideration of the impact that maternal distress may have on her ability to manage the structure and activities within the home has not been as fully captured. The current study presents a number of important findings: 1) household chaos (specifically disorganization) emerged as a significant mediator between maternal distress and each of externalizing and internalizing behaviours as well as hair cortisol levels in children; and 2) maternal distress has a direct, positive association with child hair cortisol concentration but not externalizing and internalizing behaviours. These findings are consistent with the only, to the best of my knowledge, study that assessed a similar mechanism (Hur et al., 2015). However, it adds to the literature via its inclusion of a constellation of factors in the maternal distress construct to provide a more robust assessment of its effect on household chaos and the child outcomes of interest. Further the use of hair cortisol as a measure of chronic stress adds to the growing body of work using this measure in child studies (Bates et al., 2017; Kornelsen et al., 2019; White et al., 2017). These findings provide a novel perspective regarding the capacity of the mother to regulate the home environment and the implications this has for child outcomes. Household chaos is a plausible variable through which maternal functioning may impact child outcomes but given the dearth of literature examining this mechanism, further replication studies need to be conducted on a larger scale and with diverse samples. Further, future studies should also consider

the inclusion of fathers and other caregivers within the home as there may be differences in the ways in which their own levels of distress may affect child socioemotional and stress physiology outcomes.

5.2 Future Considerations and Implications

This dissertation sought to provide a novel, multi-method examination of the effects of household chaos on multiple domains of child functioning. Informed by the theoretical foundations of Bronfenbrenner's bioecological theory of human development, the collective findings demonstrated that household chaos has an adverse, direct effect on child executive functioning, socioemotional behaviours and stress physiology. From a theoretical perspective, these findings suggest that children living in chaotic environments are at risk of experiencing an interference to the proximal processes that shape their development. Specifically, chaos provides a climate of disorder and inconsistencies that promote outcomes of dysfunction (e.g. deficits in executive functioning, elevated problem behaviours, HPA axis dysregulation). Further, it also interferes with parenting practices which serve as an essential proximal process in early childhood. In addition, these findings also introduce the idea that maternal capacity can regulate the levels of chaos in the home, which may compound the negative effects on proximal processes. These findings overall highlight the complex array of factors at play within the home environment that all contribute to the overall functioning of the child.

Beyond its theoretical importance, these findings can also inform future research design. First, more longitudinal research in the area of household chaos is needed. Few studies have examined the effect of household chaos on child outcomes longitudinally (e.g. Blair, Berry, Mills-Koonce, Granger, & FLP Investigators, 2013; Deater-Deckard et al., 2009; Hart, Petrill, Deckard, & Thompson, 2007; Vernon-Feagans et al., 2016; Zvara et al., 2014). These provide

important insights into the stability of chaos, its effects on the development of child outcomes and provides an understanding of the direction of effects. Second, given the limited shared variance between questionnaires and direct assessments (Toplak et al., 2013), future studies should consider multi-method approaches to examining executive functioning in order to minimize the effects of the biases inherent to questionnaires (Joyner, Silver, & Stavinoha, 2009) and the rigidity of direct assessments (Chaytor, Schmitter-Edgecombe, & Burr, 2006) and ensure a robust and accurate understanding of executive functioning in children. Third, this dissertation's examination of both dimensions of household chaos demonstrated the differential effects on child outcomes. To date, the operationalization of household chaos has been varied. This dissertation demonstrates the importance of ensuring that future studies properly represent both for a more thorough examination of its effects. Finally, measurement of maternal distress has varied significantly in the literature; future research can better elucidate the factors that best provide an ecological measure of maternal functioning in order to provide some standardization in measurement and consistency in findings.

Collectively, these findings also provide important insights for prevention and intervention research by highlighting the importance of targeting the physical environment within which children and families reside. Future intervention studies should focus on ways to provide families with the resources needed to create greater order and stability within the home. This may involve, for example, helping parents to establish consistent routines for different parts of the day (e.g. meals, bedtime). It may also involve examining potential buffers that may mitigate the effects of chaos in the home (e.g. structured child care; Berry et al., 2016). Ultimately, programs tailored to stabilize the home environment as well as support mothers'

physiological and psychological health and encourage more sensitive and responsive caregiving practices will set the foundation for healthy developmental trajectories for children.

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