Specific Parenting Behaviours Associated with Children's Internalizing and Externalizing Behaviours: Differential Susceptibility Based on Autonomic Function & Sex

by

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Abstract

Parenting quality is robustly associated with the development of psychopathology, yet children's outcomes can be substantially different despite experiencing similar early caregiving environments. Several factors may underlie broad variability in outcomes linked to parenting, including the child's sex and physiological markers of behavioural regulation, such as autonomic nervous system (ANS) function. Greater specificity is needed to elucidate how parenting is associated with preschool-age children's behaviour problems, particularly among children more broadly at risk of maladjustment. Parent-child dyads (N=100) experiencing socioeconomic adversity completed a joint problem-solving task while children's parasympathetic (PNS) and sympathetic nervous system (SNS) activity were indexed via heart rate variability and pre-ejection period, respectively. Specific affective and strategy-oriented parenting behaviours were coded for frequency during the task. Cardiac autonomic balance (CAB) and cardiac autonomic regulation (CAR)—coordinated and opposing action of the PNS and SNS, respectively—were examined as moderators linking parenting to children's internalizing and externalizing behaviours. Child sex was included as a secondary moderator. Results demonstrated that low levels of parent praise were associated with more externalizing behaviours, specifically for males. Low CAR, or coinhibition of PNS and SNS activity, was related to more externalizing problems. Children with high CAR, or greater coactivation of SNS and PNS activity, displayed the fewest internalizing behaviours in the context of high parental praise. Parents' more frequent expression of positive emotion was linked to more internalizing behaviours in females. Results support a differential susceptibility theory suggesting that children may be or less sensitive to specific aspects of positive parenting, depending on their sex and autonomic activity.

Key words: parenting, preschool, internalizing, externalizing, autonomic nervous system, cardiac autonomic balance, cardiac autonomic regulation

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Table of Contents

List of Tables

List of Figures

Specific Parenting Behaviours Associated with Children's Internalizing and Externalizing Symptoms: Differential Susceptibility Based on Autonomic Function & Sex

The preschool years are a critical developmental period when children gain independence from caregivers and shift towards more independent regulation of emotions, behaviour, and arousal (Rothbart et al., 2011). Parents play an important role in scaffolding children's self-regulation, which is crucial for long-term adaptive functioning including academic achievement, social competence, and mental health (Robson et al., 2020). Parenting characterized by high sensitivity and support has been linked to adaptive coping, lower negative emotionality, and fewer behaviour problems in young children (Paulussen-Hoogeboom et al. 2007; Smith et al., 2010). In contrast, intrusive and controlling parenting is associated with deficits in executive functioning and early internalizing and externalizing problems (Eisenberg et al., 2015; Rudd et al., 2017; Yan & Ansari, 2017). However, a differential susceptibility theory suggests that some children may be more or less sensitive to early caregiving experiences, which can lead to significant variability in outcomes across children (El-Sheikh et al., 2013; Erath et al., 2009; Rudd et al., 2017). A number of factors are proposed to influence children's sensitivity to early caregiving, including the child's sex (e.g., Boeldt et al., 2012) and biological markers underlying self-regulatory capacities (Erath et al., 2009; Rudd et al., 2017)

In particular, the autonomic nervous system (ANS) has received much attention as a biomarker of self-regulatory capacities, with the parasympathetic branch (PNS) of this system linked to aspects of behavioural regulation (e.g., Beauchaine & Thayer, 2015) and the sympathetic branch (SNS) linked to sensitivity to rewards and impulsivity (Peters et al., 2018). Children's differential susceptibility to maladjustment linked to ANS function has been observed under a variety of adverse contexts, including poverty-related stress (e.g., Hagan et al., 2016) and poor parenting quality (e.g., Rudd et al., 2017). While most studies have examined the

independent influence of SNS and PNS activity, recent research highlights the importance of examining the interplay between autonomic branches which more accurately reflects ANS activity and associated regulatory function (El-Sheikh et al., 2009; Kopp & Ram, 2018). Differences in cardiac autonomic balance (CAB) and cardiac autonomic regulation (CAR)—coordinated and opposing action of autonomic branches, respectively—have been associated with various health-related outcomes (e.g., diabetes, heart attack; Berntson et al., 2008). However, few studies have examined CAB and CAR in the context of developmental psychopathology. Some evidence suggests that opposing action of autonomic branches may be a vulnerability factor for heightened behaviour problems in adverse family contexts (e.g., marital conflict; El-Sheikh, Keiley, Erath, & Dyer, 2013; El-Sheikh et al., 2009), but methodological differences across studies limit generalizability to younger children and other risk contexts, including low socioeconomic status.

The present study aimed to clarify how parenting behaviours are associated with preschool-age children's early behaviour problems, particularly in the context of socioeconomic risk. Differential susceptibility to internalizing and externalizing behaviours was examined based on children's ANS function, reflected by measures of reciprocal and opposing action of both autonomic branches (i.e., CAB and CAR, respectively). Child sex was also considered as a potential moderator given that notable sex differences emerge in the preschool period, including parent socialization practices (e.g., Endendijk et al., 2017), rates of behaviour problems (Keenan & Shaw, 1997; Rutter et al., 2003), and how ANS is linked to behaviour regulation (e.g., Beauchaine, 2001). A more comprehensive review of relevant literatures integrating developmental psychopathology and psychophysiology is provided in the following sections.

Parenting, Children's Self-Regulation, and Early Behaviour Problems

Self-regulation is the ability to independently enact appropriate behavioral and emotional responses to effectively manage arousal and achieve a desired goal (Clelland et al., 2015). The emergence of self-regulation occurs in the first few years of life when children shift from external to internal control of behaviour and affect (Eisenberg et al., 2010). Parents can facilitate children's self-regulation by scaffolding and praising independent initiatives at problem-solving, structuring the environment with clear guidelines, taking their child's perspective, and granting autonomy (Deci & Ryan, 1985; Grolnick et al., 2007). In contrast, parenting characterized by overcontrolling, excessive directiveness, and intrusiveness can undermine children's sense of autonomy and limit their independent regulation during novel or challenging situations (Eisenberg et al., 2015; Rudd et al., 2017; Yan & Ansari, 2017). Deficits in self-regulation linked to inadequate parenting can lead to emotional and behavioural dysregulation which may manifest in behaviour problems including both internalizing (e.g., fearfulness, shyness, or detachment) and externalizing symptoms (defiance, aggressiveness, and hyperactivity; Eisenberg et al., 2015; Yan & Ansari, 2017).

Studies of parenting influences on children's behaviour problems have primarily examined parenting along dimensions, such as support-control (Galambos et al., 2003; Grolnick et al., 2007; Paulussen-Hoogeboom et al., 2007) and positive-negative parenting (Boeldt et al., 2012; Dallaire et al., 2010; Tung et al., 2012). Negative parenting behaviours like over-controlling, intrusiveness, or excessive negative emotion can undermine children's sense of autonomy and emotional safety and threatens positive adjustment by limiting a children's ability to develop independent coping skills (Eisenberg et al., 2015; Rudd et al., 2017; Yan & Ansari, 2017). Negative parenting behaviours including harsh punitiveness and control have been robustly linked to internalizing and externalizing problems in early childhood (Eisenberg et al., 2015; Dallaire et al., 2010; Rudd et al., 2017; Yan & Ansari, 2017). While studies tend to focus

on the detrimental effects of negative parenting or early adversity, low levels of positive parenting have also been associated with higher rates of behaviour problems in preschoolers (Paulussen-Hoogeboom et al., 2007).

Supportive-positive parenting includes affective and behavioural characteristics that would make a child feel accepted and approved, which can foster a sense of security and promote positive adjustment (Morris et al., 2017). Parenting behaviours like scaffolding, praise, positive regard, and autonomy-granting have been associated with a range of positive outcomes including preschool children's adaptive coping during stress (Power, 2004) and fewer internalizing and externalizing problems over time (Boeldt et al., 2012). The protective role of positive parenting has also been demonstrated in adverse environments (Kim-Spoon et al., 2012; Song et al., 2018). For example, higher levels of positive parenting in the context of socioeconomic risk predicted fewer externalizing and internalizing behaviours among preschool-age children (Whiteside-Mansell, Bradley, & McKelvey, 2009). Fewer studies have explicitly explored the risk associated with a lack of positive parenting. Inadequate or infrequent parental guidance, support, and positive regard may prohibit children's development of early self-regulatory capacities and limit their ability to effectively manage behaviour and emotions independently (Karreman et al., 2006; Landry et al., 2006). Early theories suggested potentially even more risk-associated with a lack of positive parenting than the presence of negative parenting (Pettit & Bates, 1989). This has been supported in studies of older children and adolescents which demonstrate greater dysregulation linked to less frequent positive parenting, over and above the risk associated with negative parenting (Dallaire et al., 2006; Yap et al., 2010). The effects of low positive parenting may be even more pronounced in low-income families, with more child negative emotionality being reported in socioeconomically

disadvantaged children and the reverse being true in more affluent families (Paulussen-Hoogeboom et al., 2007).

There is substantial evidence that both positive and negative aspects of parenting are associated with the development of children's behaviour problems. However, methodological differences and variable conceptualizations of parenting dimensions has led to discrepant findings across studies. In particular, the link between negative parenting and internalizing problems has been variable, with some studies linking high levels of parent control and intrusiveness to internalizing behaviours in preschool (Bayer et al., 2006; Laurin et al., 2015) while others have found no association (Campbell et al., 2007; Keiley et al., 2003) or a stronger association with externalizing problems (Rudd et al., 2017). Similarly, associations between supportive parenting and children's externalizing behaviours are unclear, with some evidence suggesting an inverse relationship (Belsky et al., 2007; Eisenberg et al., 2005), no association (Spinrad et al., 2007), or a protective role of supportive parenting (Boeldt et al., 2012).

Inconsistent findings may be due to differences in how parenting is conceptualized and examined across studies. For example, studies of internalizing problems have focused more on affective components of parenting (e.g., positive/negative regard, warmth and sensitivity; Wagner et al., 2016) whereas studies of externalizing behaviours have focused on behavioural or strategy-oriented aspects of parenting (e.g., control, over-directiveness; Eisenberg et al., 2015). There may be nuanced differences in how affective and strategy-oriented parenting characteristics are associated with children's outcomes that is not captured with dimensional measures of parenting (Eisenberg et al., 2001; Mullineaux et al., 2009). For example, parental emotion expressivity may facilitate children's internalization of how much and what types of emotional expression are effective and appropriate, which may have important implications for children's socioemotional competence, emotional understanding, self-esteem, and affect

regulation (Eisenberg et al., 2001; Ogren & Johnson, 2021; Strayer & Roberts, 2004). Conversely, behavioural or strategy-oriented components of parenting, such as scaffolding, praise, and positive control may additionally function to guide children's problem-based learning, promote a sense of competence, and structure the environment to support effective independent behavioural regulation (Bernier et al., 2010; Dennis, 2006). There is some evidence that discrete parenting components can have distinct effects on children's outcomes, including stronger associations between internalizing behaviours and mothers' expression of positive compared to negative emotion (Eisenberg et al., 2001). Affective parenting components (e.g., neglect, rejection) have also been demonstrated to have the strongest effects on children's delinquency, while strategy-oriented components (e.g., parental monitoring) had only moderate effects (Hoeve et al., 2009). A more precise examination across parenting components will be important for distinguishing the specific effects of parenting on children's early internalizing versus externalizing problems.

Another possible reason for differences in how parenting is linked to internalizing and externalizing problems are sex differences that can begin to emerge in the preschool period. First, different rates of internalizing and externalizing problems can be observed, with males generally displaying more externalizing problems and females displaying more internalizing problems (Boeldt et al., 2012; Miner & Clarke-Stewart, 2008; Zahn-Waxler et al., 2008). Differential exposure to parenting based on children's sex, including different socialization principles, may also lead to sex differences in children's self-regulation and associated behaviour problems. Evidence for sex-based differences in parenting has been mixed; generally, more positive and less negative parenting has been observed among girls and the reverse has been true for males, but some studies demonstrate relatively small effects (Endendijk et al., 2016; Leaper, 2002). Assuming directionality of this association has also been cautioned given that parent-child

interactions are reciprocal, and parents may respond to characteristics of their child including behaviours which show sex-based differences (Pettit & Arsiwalla, 2008). A third possibility is that male and female children may be sensitive to different types of parenting. Based on differential susceptibility theory, there is some evidence that males may be more influenced by both negative and positive parenting (Barnett & Scaramella, 2013; Rutter, et al., 2003). For example, less positive and more negative parenting has been more strongly linked to externalizing problems in boys compared to girls (Boeldt et al, 2012), while other studies find this effect only in boys (Calkins, 2002; Miner & Clark-Stewart, 2008; Tung et al., 2012). Children's sex has been demonstrated to moderate parenting associations primarily among older children and adolescents, so there is need to examine these associations in the preschool period when sex differences are likely to emerge (Boeldt et al., 2012). Given the multitude of external factors that might exert influence on children's outcomes, there has been increasing emphasis on moderating influences that may be involved in exacerbating or reducing the likelihood of psychopathology linked to parenting. Differential susceptibility to caregiving environments is also suggested to vary based on underlying biological vulnerability or protective factors such as children's ANS activity, which is intricately linked to affective and behavioural regulation.

ANS and Children's Susceptibility to Early Behaviour Problems

Individual differences in ANS activity are thought to underlie broad variability in how parenting is linked to children's internalizing and externalizing problems (Abaied et al., 2018; Erath et al., 2009; Rudd et al., 2017; Wagner et al., 2016). Traditionally, highly reactive children were viewed as being vulnerable to adverse experiences, displaying the greatest maladjustment compared to less reactive children (Monroe & Simons, 1991). This "diathesis stress" hypothesis was later reinterpreted in light of findings which demonstrated that highly reactive children are more vulnerable to adverse contexts but also display more adaptive functioning in positive

contexts (Boyce et al., 1995). The differential susceptibility theory developed out of these findings, which states that children differ in how they are influenced by their environment in a "for better or for worse" manner (Belsky & Pluess, 2009; Boyce & Ellis, 2005). For example, high physiological reactivity may confer psychological risk in the context of negative parenting but promote the greatest benefit from supportive parenting. There is considerable evidence to support the differential susceptibility theory and several studies have implicated ANS activity as a moderator linking children's early caregiving environment to psychopathology outcomes (Abaied et al., 2018; Erath et al., 2009; Rudd et al., 2017).

Autonomic Nervous System (ANS)

The ANS is comprised of two systems—the parasympathetic nervous system (SNS) and sympathetic nervous system (SNS)—which flexibly coordinate activity to regulate cardiac functioning, indirectly modulating regulation of behaviour and affect (Porges et al., 1994). The parasympathetic nervous system (PNS) is the branch of the ANS that regulates heart rate via the vagus nerve which facilitates down-regulation of physiological arousal by slowing cardiac rhythms when activated (Porges et al., 2004). PNS function is typically indexed by high-frequency heart rate variability (HRV), commonly referred to as respiratory sinus arrythmia (RSA), which increases with increasing parasympathetic influences on heart rate (Porges et al., 2001). During restful periods, PNS activity exerts an inhibitory influence on the heart, acting similarly to a cardiac "brake", which contributes to a slow and steady heart rate. During increased stress or environmental demand, the brake is disengaged and withdrawal of PNS activity supports an increased and more variable heart rate that can facilitate a greater range of behaviour and adaptive regulation. Optimal PNS activity depends on context, so that PNS withdrawal (when the brake is disengaged) may be adaptive during a challenging task which requires regulatory processes like behavioural control, while PNS activation may be warranted in

more emotionally salient situations that necessitate effective calming strategies (Graziano & Derefinko, 2013). The ability to flexibly regulate activity of the PNS and maintain homeostasis in the face of changing demands is therefore a marker of adaptive behavioural regulation (Beachaine & Thayer, 2015). Given its role in facilitating regulation and adaptive functioning, individual differences in PNS activity are thought to underlie children's dysregulated behaviour (Boyce et al., 2001; Hinnant & El-Sheikh, 2009; Quiñones-Camacho & Davis, 2018; Stifter et al., 2011)

The SNS is the second branch of the ANS which is activated during times of stress to prepare the body for a "fight or flight" response, which facilitates increased arousal and attention to manage external demands. SNS activity can be indexed by measuring pre-ejection period (PEP), the time between the heart filling with blood and when blood is ejected. A shorter PEP indicates sympathetic activation which contributes to a more rapid cardiac cycle reflected in an increased heart rate (Bubier et al., 2009; Cacioppo et al., 1994). Activation of the SNS results in a more robust and prolonged state of arousal which is more difficult and metabolically costly to regulate, relative to the PNS (Beauchaine, 2001; Porges et al., 1994). SNS activation in the context of stress is generally considered to be adaptive because it promotes mobilization of behaviours to effectively manage environmental demands. Conversely, blunted SNS response has been linked to reduced behavioural regulation and associated problems including reward sensitivity, impulsivity, and hyperactivity (Beauchaine et al., 2013; Graziano & Derefinko, 2013; Hinnant et al., 2017)

ANS and Psychopathology

PNS and SNS activity are both influenced by and moderate the influence of contextual factors on psychological outcomes (Belsky & Pluess, 2009; Boyce & Ellis, 2005). Adverse experiences during sensitive periods of development, including poverty-related stress and a poor

parent-child relationship, can become biologically embedded in children's physiology which has implications for later ANS function and behavioural regulation across contexts and throughout development (Johnson et al., 2017; Propper & Holochwost, 2013). Certain patterns of ANS activity acquired through experience may stabilize and become trait-like and subsequently operate as vulnerability or protective factors for dysregulated behaviour (Eisenberg et al., 2001; Beauchaine & Thayer, 2015). Several studies have identified individual differences in PNS and SNS function that underlie differential susceptibility to both supportive contexts (Abaied et al., 2018; Bubier et al., 2009; Wagner et al., 2016) and environmental risk such as marital conflict (El-Sheikh et al., 2013, 2009), intrusive parenting (Rudd et al., 2017), and poverty (Busso et al., 2017; Johnson et al., 2017). However, significant variability exists across studies which limits conclusions about specific patterns of PNS and SNS activity that can be universally characterized as risky or protective.

Adaptive or maladaptive PNS and SNS activity depends on a number of factors that vary widely across studies, including child age and sex (El-Sheikh et al., 2013; Rudd et al., 2017; Salomon et al., 2000), the context in which ANS is measured (Cipriano et al., 2011; Obradovíc et al., 2011; Rudd et al., 2017), and whether ANS activity is examined at rest or as reactivity (Cipriano et al., 2011; El-Sheikh et al., 2013). Additionally, the majority of research linking ANS activity to children's psychopathology has assessed the PNS and SNS separately, which involves either overlooking or inferring activity in the other branch. Studies have disproportionately focused on the function of the PNS, given its more explicit role in facilitating behavioural and affective regulation,. However, there is evidence that PNS activity linked to behaviour regulation may vary based on trait-like activity of the SNS (El-Sheikh et al., 2009; Knight et al., 2020) and that children's blunted SNS response is associated with greater behavioural disinhibition, impulsivity, and hyperactivity linked to the family environment (Beauchaine et al., 2007). A

more accurate measure of autonomic functioning is in the coordination or interaction of parasympathetic and sympathetic branches (Berntson et al., 2008; Gatzke-Kopp & Ram, 2018; Stone et al., 2020). Considering the interaction of both branches will allow for greater specificity in characterizing how ANS activity influences children's susceptibility to behaviour problems linked to early caregiving experiences.

Cardiac Autonomic Balance (CAB) & Cardiac Autonomic Regulation (CAR)

Studies that examine autonomic branches as separate entities are generally limited given that the PNS and SNS do not operate independently from one another. Rather, their coordinated action functions to maintain homeostasis under relatively normal circumstances in order to meet environmental demands (Berntson et al., 2008; Stone et al., 2020). Dysregulated or uncoordinated action of autonomic branches is thought to underlie behavioural dysregulation that can manifest in internalizing or externalizing problems (Bauer, Quas, & Boyce, 2002; El-Sheikh et al., 2009). Early conceptualizations of autonomic function had assumed ANS activity is reciprocally determined, such that increased activity in one branch is accompanied by decreases in the other (Porges, 1992). However, exceptions to this pattern are commonly observed including opposing action of branches reflected in co-activation or co-inhibition of PNS and SNS activity (Bernston et al., 1991). While few studies have examined PNS and SNS interactions in the context of developmental psychopathology (Brush et al., 2019; El-Sheikh et al., 2009; El-Sheikh et al., 2013), assessments of interacting PNS and SNS activity have been proposed in the medical literature including cardiac autonomic balance (CAB) and cardiac autonomic regulation (CAR; Berntson et al., 2008).

CAB refers to reciprocal activation of autonomic branches where both the PNS and SNS promote the same physiological response. High CAB, or *reciprocal parasympathetic control, is c*haracterized by PNS activation and SNS inhibition that downregulates arousal, which may be

most appropriate in situations that require a calm physiological state. Low CAB, or *reciprocal sympathetic control*, refers to SNS activation and PNS inhibition that upregulates arousal and increases heart rate and behavioural activation, which is likely beneficial for adjusting to challenges or stress. CAB is a measure of coordinated functioning of the PNS and SNS which is likely to contribute to an efficient physiological response and adaptive behavioural regulation depending on the context (Berntson et al., 2008; El-Sheikh et al., 2009).

CAR refers to uncoordinated action of the autonomic branches where the PNS and the SNS promote opposing physiological responses. Low CAR reflects *coinhibition* characterized by decreased action of both the PNS and SNS; parasympathetic withdrawal may facilitate increased behavioural regulation to meet contextual demands, yet while being coupled with an insufficient sympathetic response. High CAR reflects *coactivation* characterized by increased action of both branches; sympathetic activation may lead to increased arousal, while the parasympathetic branch is simultaneously engaged to reduce arousal and promote effective behavioural regulation. Opposing PNS and SNS activity may suggest maladaptive physiological regulation where one branch is insufficient for performing adaptive functions in response to a stressor. Alternatively, it may reflect an ambivalent physiological response which occurs when the optimal level of arousal to a novel or challenging situation is ambiguous or when maintenance of a baseline state of arousal is warranted in the absence of a challenge (Berntson et al., 1991; El-Sheikh et al., 2009).

CAB/CAR & Children's Behaviour Problems

Reciprocal parasympathetic and sympathetic activation are considered to be normative responses to stress and are associated with more adaptive outcomes, depending on the context (Berntson et al., 1994; Salmon et al., 2000). In contrast, opposing action of the PNS and SNS has been associated with higher levels of stress exposure and implicated as a vulnerability factor for

maladaptive outcomes. For example, six to seven year-old children who exhibited greater coinhibition in response to a challenging task displayed the highest levels of externalizing problems (Boyce et al., 2001). Similarly, youth who displayed coinhibition consistently across a variety of laboratory stressors reported the most hostile affect, and also reported the greatest exposure to family conflict (Salomon et al., 2000). However, the majority of studies investigating CAB and CAR as predictors of children's adjustment do not consider children's broader environmental context, such as parenting, which misses important information that may influence children's likelihood of developing behaviour problems. Relative activity of the PNS and SNS are likely to increase or decrease susceptibility to psychopathology depending on the context; that is, the influence of children's early environment on behavioural and emotional adjustment may depend on their autonomic activity.

Evidence for possible interactions between children's early environment and CAB and CAR is considerably limited, particularly for the preschool period. The most notable findings are in the context of marital conflict in middle childhood, which identified coinhibition and coactivation as vulnerability factors and reciprocal PNS and SNS activation as protective factors for externalizing problems (i.e., delinquency, aggression, conduct problems, and attention deficit-hyperactivity; El-Sheikh et al., 2009). Coinhibition similarly emerged as vulnerability factor for increasing depression and anxiety symptoms over time, particularly for girls (El-Sheikh et al., 2013). Caution in generalizing these findings to other contexts including the broader caregiving environment is warranted for a number of reasons.

Early caregiving experiences are likely to include both positive qualities and normative levels of risk, which will inevitably differ in how these experiences become embedded in children's physiology compared to higher risk contexts. High marital conflict may contribute to more chronic states of arousal leading to physiological wear and tear, which can result in

eventual dysregulation (El-Sheikh & Hinnant, 2011). Second, there is little understanding of how CAB and CAR interact with more supportive contexts and whether children may be differentially susceptible to positive aspects of the caregiving environment. One study provided evidence for differential sensitivity to supportive contexts in four-to-six year old children, but this was in the context of experimentally-manipulated support from an adult researcher and examined effects on memory rather than psychopathology outcomes (Quas et al., 2004). Nonetheless, this study demonstrated that higher reciprocal sympathetic activation was associated with better memory in the context of high support, but worse memory in the context of low-support, supporting the differential susceptibility theory. Third, while current studies of CAB and CAR have demonstrated some sex-differences in susceptibility to internalizing problems (El-Sheikh et al., 2013), the fact that no sex differences were observed for externalizing problems is in contrast to other studies on interactions between the familial environment and physiological reactivity (El-Sheikh, 2005; El-Sheikh et al., 2001).

Given that the literature on CAB and CAR in relation to psychological measures in general is underdeveloped, generalizability of current empirical findings is limited. In particular, almost no studies of CAB and CAR have included children of preschool age, despite this being a critical period of development when early experiences can exert influence on both physiological programming and the early development of behaviour dysregulation (Porges & Furman, 2011). With the relative novelty of research on interactions between autonomic branches, further study is needed to describe CAB and CAR, particularly in the context of developmental psychopathology. More specifically, comprehensive investigations are needed to better understand how interactions between both branches of the ANS may impact children's behavioural outcomes related to early caregiving experiences.

The Present Study

The present study aimed to provide greater clarity on the association between parenting and preschool-age children's early behaviour problems, particularly in the context of socioeconomic risk. In particular, there is a lack of specificity in current measurements of parenting across studies, with the majority considering broad parenting dimensions that do not capture nuanced differences between affective and strategy-oriented parenting behaviours. The first goal of this study was to investigate associations between discrete components of parenting and children's internalizing and externalizing behaviours, which may have important implications for clarifying broad variability in children's parenting-linked behavioural outcomes. Given such variability, there is also an increasing need to better understand possible underlying vulnerability or protective factors that may influence how children develop psychopathology under different caregiving environments. In particular, individual differences in children's physiology, including the coordinated or opposing action of ANS branches, may lead to some children being more or less sensitive to specific parenting behaviours. Males and females may also be differentially susceptible to early caregiving and evidence different rates of internalizing and externalizing behaviours. The second goal of this study was to investigate both child sex and patterns of SNS and PNS activity as possible moderators linking parenting to children's behaviour problems. In contrast to a large majority of studies examining psychopathology associated with high risk contexts (e.g., maltreatment, family violence), this study investigates associations in the context of socioeconomic risk that may allow for observation of more normative parenting characterized by both positive/supportive and less extreme negative behaviours.

Methods

Participants

The sample consisted of 100 caregiver-child dyads recruited in partnership with the Head Start program in Lane County, Oregon for a larger intervention project (N=266). All participating caregivers had primary custody of their child and both members of the dyad were fluent in English with no prior history of head trauma or neurological disorder. Participating children were between 37.2 and 64.4 months (M = 51.61, SD = 6.51). The sample included 50 (51.6 %) male children and 47 (48.5%) female children (unspecified, n = 3). Primary caregivers were predominantly mothers (n = 84, 86.6%; fathers: n = 12, 12.4%) with an average age of 33.4 years (SD = 8.00 ; range = 22 - 67). The majority of caregivers reported being married (n = 38, 44.7%), followed by living with a partner (n = 19, 22.4%), and single (n = 18, 21.2%). Ethnicity was reported as Hispanic/Latinx (n = 13, 21.0%) or non-Hispanic/Latinx (n = 49, 79.0%); unspecified, n = 38. Given that Head Start programming typically supports families living at or below the poverty line, many families came from households with relatively low annual household income and caregiver education. Primary caregiver education was coded on a 6-point scale with responses ranging from 1 (Less than 7th grade) to 6 (Graduate college, Masters or PhD*)*. The median caregiver education level was partial college or trade school. Annual household income was coded on a 10-point scale with responses ranging from 1 ($0 - $5000) to 10 ($50000-$70000), median = $15000-$20000. Sample characteristics are reported in Table 1.

Procedure

Participants first completed an intake interview to obtain consent and to complete a battery of questionnaire measures including demographics, caregiver self-reports, and caregiver-reports of child characteristics. For the purposes of this study, only the Preschool-Kindergarten Behaviour Scales (PKBS) will be discussed in detail. Following the intake interview, caregiver-child dyads were invited to the laboratory to complete a battery of tasks while cardiac physiology was measured (full details described below). Assessments began with electrode application on

both caregiver and child (only child physiology was analyzed in this study) followed by a brief baseline physiological measurement while dyads watched a neutral, calming video of ocean scenes. The dyad then completed a series of individual executive function tasks (not discussed here) and then reunited to complete a moderately challenging joint problem-solving task, which is the focus of the current study. In the joint problem-solving task, dyads were seated at a table together and the child was given 12 disassembled Duplo blocks and an assembled Duplo block model of an animal. Parents were instructed to verbally assist their child in building a replica of the block animal, but they were prohibited from physically touching any of the blocks. Dyads were given 5-minutes to complete the replica before a research assistant re-entered the room and terminated the task. Physiological data was collected throughout the entirety of the video-recorded laboratory assessment, with a final measurement obtained while dyads watched a second neutral video of ocean scenes at the end of the visit.

Autonomic physiology data acquisition

Caregivers were guided in the application of 11 disposable pre-gelled electrodes on their child for simultaneous measurement of electrocardiography (ECG) and impedance cardiography (ICG), as indices of HRV and PEP respectively. ECG data was obtained via three electrodes applied in a modified Lead II arrangement on the distal end of the right clavicle, the lower left rib cage, and the lower abdomen. ICG, or Z_0, was obtained via eight electrodes applied in a tetrapolar formation on the left and right lateral neck and torso. ECG and ICG data were obtained at a sampling rate of 500Hz and sent wirelessly from Biopac Nomadix BN-RSPEC and BN-NICO transmitters to a Biopac MP150 acquisition system. The resulting data was later processed by trained research assistants using Mindware HRV and IMP software (Westerville, OH; www.mindware.com). Data was visually inspected to confirm heart beats in 30-second epochs and Q and B placement for processing PEP. The resulting interbeat interval was natural

log-transformed and power in the respiratory frequency band was derived from the spectral density function to estimate HRV values. Based on respiration norms for this age-range, the high-frequency band was set from 0.24 to 1.04 Hz (Bar-Haim, Marshall, & Fox, 2000). HRV values were then averaged across 30-second epochs to derive baseline and task HRV values. PEP was indexed from the first-order derivative of the ICG signal and calculated as the length of time from the Q-point of the ECG waveform to the B-point of the dZ/dt waveform. As with HRV, PEP values were averaged across 30-second epochs to derive baseline and task values. For both HRV and PEP, epochs were included in final averaging if 1) at least 50% of the data in a given epoch was usable, and 2) at least 50% of epochs in a given task were usable.

Preliminary analysis of cardiac data revealed that PEP data for a large number of participants was not usable during the problem-solving task due to movement-related electrical artifacts. In order to preserve as much as of the sample as possible for statistical analysis, analysis of PEP was restricted to baseline values. CAB was quantified as the difference between normalized values of task HRV and baseline PEP [CAB=HRVz-(-PEP)], with lower scores indicating reciprocal parasympathetic dominance and higher scores indicate reciprocal sympathetic dominance. Negative PEP values are used because SNS activation is associated with shorter PEP values, so the relationship was inverted to create a positive association. CAR was calculated as the sum of normalized task HRV and baseline PEP [CAR=HRVz+(-PEPz)], with lower scores indicating parasympathetic and sympathetic coinhibition and higher scores indicating coactivation (Berntson et al., 2008).

Preschool and Kindergarten Behaviour Scales (PKBS)

Caregiver reports of children's behaviours were collected using the PKBS, a 76-item behaviour rating instrument for use with children age 3 to 6 (Merrell, 1996). The PKBS includes two separate scales: *Social Skills* and *Problem Behaviours*. The Social Skills scale includes 34-

items across three subscales of *Social Cooperation, Social Interaction,* and *Social Independence*. The Problem Behaviour scale includes 42-items across two subscales of *Internalizing Problems* and *Externalizing Problems*. Within the Externalizing Problems subscale, three narrow scales derive ratings on *self-centered/explosive, attention problems/overactive*, and *antisocial/aggressive* behaviours; within the Internalizing Problems scale, two narrow scales derive ratings on *social withdraw* behaviours and *anxiety/somatic problems*. For the purpose of this study, only the Internalizing Problems and Externalizing Problems subscales were used. The PKBS has excellent psychometric properties with a range of .84 - .97 for internal consistency and .62-.87 for test-retest reliability, with acceptable criterion validity.

Observational coding of dyadic interactions

Caregiver and child behaviours were assessed by trained undergraduate research assistants using a laboratory-developed observational coding scheme adapted from a model proposed by Stansbury and Sigman (2000). The model features specific behaviour codes which assess parental ability to scaffold children' self-regulation in relation to objects and emotions as well as children's own ability to self-regulate during a challenging task (only caregiver behaviour codes are discussed here). Five categories were identified as relevant and observable caregivers behaviours: negative emotion reactions, positive emotion reactions, control, praise, and task-strategizing (support). Examples for each code are listed in Table 2. Dyadic interactions were coded in 30-second intervals for the 5-minute duration of the joint problem-solving task. If the child completed the task before the allotted time, interactions were coded for 20-seconds past successful completion of the task (i.e., when the child successfully constructed the Duplo block replica). Of the 100 dyads, n = 52 completed the task in under 5-minutes or ten 30-second blocks (M = 7.91 blocks, range = 3 – 10 blocks). Both verbal utterances and gestures were coded within each category, and the frequency of behaviours was recorded and tallied to

derive a total count for each code. Twenty-five percent of videos were double-coded by trained undergraduate research assistants to maintain interrater reliability.

Preliminary Processing of Parent Codes

Reliability analysis

Interrater reliability was assessed using single measure absolute agreement intraclass correlations in a two-way random effects model. Raters had acceptable to high reliability across videos (.75 - .97) and codes (.72 - .85).

Data correction and reduction

To account for variable duration of task length across participants, frequency counts of parenting codes were adjusted by the total time to create a scale of each behaviour count. Behaviour counts were divided by the proportion of completed blocks out of a possible ten for participants who took less than the standardized 5-minutes to complete the task (e.g., if 20 counts were observed over 5 out of 10 blocks, total count = 20 ÷ 5/10 = 40). After transformation of frequency counts, initial review of data highlighted notable variability between frequency code types (see Table 3 for descriptive statistics on parenting codes). Variability in quantity and distribution of codes is consistent with other similar coding schemes (e.g., O'Connor et al., 2013) and expected given the novelty of the coding scheme. To ensure consistent variable format and maximize interpretability, all codes were dichotomized (0 = low, 1 = high) which was preferred to the problematic skew and floor effect of some codes where the majority of participants had a frequency of 0. A median split was used to dichotomize parent codes into low and high. For codes where a frequency of 0 was observed in >50% of participants (Negative Emotion Reactions, Control), codes were dichotomized as low = 0 and high > 0, which was also consistent with a median split.

Data Analytic Strategy

Preliminary analyses were conducted to describe sample characteristics and to compare means of variables across child sex. Independent samples t-tests compared levels of parent-reported internalizing and externalizing problems between males and females to assess sex-related difference in rates of behaviour problems. Chi-square tests examined associations between parent codes and child sex to identify differences in levels of parenting behaviours based on child sex. Bivariate associations among variables of interest and sociodemographic variables were conducted separately for males and females to identify parenting codes to include as predictors of behaviour problems and possible covariates to control for in analyses. Parent behaviour codes which were significantly correlated with either internalizing or externalizing problems for either sex were included in regression analyses. Model 2 in Hayes PROCESS macro for SPSS 27 was used to examine associations between the identified parent behaviour codes and children's internalizing and externalizing behaviours, with child sex, CAB, and CAR as potential moderators. Model 2 is a double moderation model (See Figure 1 for conceptual diagram) which examines the independent effect of two separate moderators, and therefore provides regression statistics for two different interaction terms. Child sex was included as a moderator in all models, paired with either CAR or CAB as the second moderator. The relationships which were examined included how child sex, CAR, and CAB independently moderated the association between parenting codes and either internalizing or externalizing behaviours.

Results

Descriptive and Correlational Analyses

Descriptive statistics were calculated for the total sample and relevant variables were compared across sex. Across the whole sample, PKBS scores were *M*(*SD*) = 9.86(5.14) for internalizing problems and *M*(*SD*) = 29.93(11.75) for externalizing problems. Independent

samples t-tests confirmed that internalizing (t = -.84, p = .40) and externalizing scores (t = 1.03, p = .31) did not differ between females [$M(SD)_{int}$ = 10.46(6.55); $M(SD)_{ext}$ = 28.31(11.02)] and males [$M(SD)_{int}$ = 9.30(3.22); $M(SD)_{ext}$ = 31.48(11.94)]. Chi-square tests were conducted to examine associations between parental codes and child sex. There was a significant association between praise and sex, $\chi^2(1, n = 97) = 3.81$, p = .049; females (n = 30) were more likely than males (n = 22) to receive high levels of parental praise, and males (n = 28) were more likely than females (n = 17) to receive low levels of praise. Parent control and child sex were also associated, $\chi^2(1, n = 97) = 4.93$, p = .026; males (n = 26) were more likely than females (n = 14) to receive high levels of parental control, and females (n = 33) were more likely than males (n = 24) to receive low levels of parental control. Child sex was not associated with parents' positive emotion, negative, emotion, or task strategizing. Chi-square tests were also conducted to examine associations between parenting variables and early completion of the problem-solving task. Children who completed the task early were more likely to experience low negative emotion ($\chi^2[1, n = 100] = 13.74$, $p < .001$), high positive emotion ($\chi^2[1, n = 100] = 5.61$, p = .018), high praise ($\chi^2(1, n = 100) = 17.53$, $p < .001$), and low control ($\chi^2(1, n = 100) = 4.49$, p = .030) from parents compared to children who did not complete the task early.

Bivariate associations were examined among variables of interest and possible sociodemographic covariates which are commonly associated with child behaviour or physiological measures (child age, ethnicity, marital status, parent education, annual household income). Correlations were conducted separately for males and females to identify parenting codes associated with internalizing and externalizing behaviours, which may differ by child sex. Sociodemographic covariates which were significantly correlated with internalizing or externalizing behaviours in both males and females were considered for inclusion as covariates

in regression analyses. All Pearson and point-biserial correlations between covariates and variables of interest are presented in Table 4.

Males

Parent praise was associated with internalizing (r = -.46 p = .02) and externalizing behaviours (r = -.48, p =.01) and parent positive emotion was associated with externalizing behaviours (r = -.39, p = .04). Age was associated with CAB (r = .42, p<.001), parent negative emotion (r = -.30, p = .04), but neither internalizing (r = -.27, p = .06) nor externalizing behaviours (r = -.17, p = .25). Child age was also associated with early completion of the task, such that older children tended to complete the task earlier (r = .51, p < .001). Ethnicity, parent education, annual household income, and marital status were not associated with any variable of interest. Given that parent praise and positive emotion were significantly correlated with the dependent variables of interest, both were carried forward to regression analyses, described below.

Females

Annual household income was associated with children's externalizing behaviours (r = -.35, p = .040). Parent positive emotion was associated with CAR (r = -.29, p = .048). Age, ethnicity, parent education, marital status, and parental codes were not related to any variables of interest. Income was not included as a covariate given that income data was missing for a large portion of the sample (16%) and this correlation was only significant for females. Additionally, given that the sample as a whole was low-income, the range of measurement was relatively small compared to typical indices of income that may show greater variability and potentially covary with other variables.

Moderation Analyses

Given the above analyses demonstrating associations between parent behaviours (praise, positive emotion) and children's internalizing and externalizing behaviours, regressions were conducted to examine how parent praise and positive emotion was related to children's internalizing and externalizing behaviours as moderated by child sex and physiological activity (i.e., CAB, CAR). Interactions below a significance threshold of p<.10 were explored through examination of conditional effects and visual inspection. Regression results are presented in Table 5.

Predicting Children's Externalizing Symptoms

Parent Praise, CAB, & Child Sex. Parent praise was significantly associated with child externalizing problems such that low levels of praise were associated with more externalizing behaviours (*b* = -24.45, SE = 10.46, *t* = -2.33, *p* = .024, CI: -45.46 – -3.43). An interaction between praise and child sex (*b* = 11.94, SE = 6.46, *t* = 1.85, *p* = .071, CI: -1.05 – 24.93) was examined for conditional effects which indicated that lower praise was significantly associated with more externalizing behaviours for males (*b* = -12.51, *SE* = 4.72, *t* = -2.65, *p* = .011, CI: -22.00 – -3.02), but not females (*b* = -.57, *SE* = 4.33, *t* = -.134, *p* = .895, CI: -9.27 – 8.13). See Figure 2 for visualization of the interaction. There were no main effects of CAB or child sex (*p*s>.05) and no significant interaction between parent praise and CAB (*p*>.10). The overall model was not significant, R^2 = .15, *F*(5,49) = 1.71, *p* =.150.

Parent Praise, CAR, & Child Sex. Parent praise was significantly associated with child externalizing behaviours such that lower levels of praise were associated with more externalizing behaviours (*b* = -26.48, *SE* = 11.48, *t* = -2.31, *p* = .025, CI: -49.54 – -3.41). An interaction between praise and child sex (*b* = 13.35, SE = 7.11, *t* = 1.88, *p* = .067, CI: -.95 – 27.65) was examined for conditional effects which indicated that lower praise was associated with more externalizing behaviours for males (*b* = -13.13, *SE* = 5.04, *t* = -2.61, *p* = .012, CI: -23.25 – 3.01),

but not females (b = 0.22, SE = 4.39, t = 0.05, p = 961, CI: -8.81 – 9.25). There was no main effect of CAR or child sex (ps>.05) and no significant interaction between parent praise and CAR. The overall model was not significant, R^2 = .159, F(5, 49) = 1.84, p = .122).

Parent Positive Emotion, CAB, & Child Sex. There were no main effects of praise, CAR, or sex on children's externalizing behaviours (ps>.05). There were no significant interactions between parent positive emotion and either child CAB or sex. The overall model was not significant, R^2 = .132, F(5, 49) = 1.49, p = .210.

Parent Positive Emotion, CAR, & Child Sex. CAR was significantly associated with children's externalizing problems, such that lower child CAR (low SNS and PNS activity; coinhibition) was associated with more child externalizing problems (b = -3.21, SE = 1.52, t = -2.11, p = .040, CI: -6.28 – -.15), after accounting for the effects of child sex and parent positive emotion. There were no main effects of parent positive emotion or child sex (ps>.05) and no interaction between parent positive emotion and either CAR or sex (ps>.10). The overall model was not significant, R^2 = .18, F(5, 49) = 2.13, p = .077.

Predicting Children's Internalizing Behaviours

Parent Praise, CAB & Child Sex. There were no main effects of parent praise, CAB, or child sex (ps>.05) and no interactions between parent praise and either CAB or child sex (ps>.10). The overall model was not significant, R^2 = .06, F(5, 48) = .59, p = .704.

Parent Praise, CAR & Child Sex. An interaction between parent praise and CAR (b = -1.88, SE = .98, t = -1.93, p = .060, CI: -3.85 – .08) was examined for conditional effects which indicated no significant simple effects at varying levels of CAR (ps>.05). There were no main effects of CAR or child sex (ps>.05) and no interaction between parent praise and child sex (p>.10). The overall model was not significant, R^2 = .13, F(5, 48) = 1.45, p =.223. Given that the main effect of child sex (t = 0.07, p = .941) and the sex by praise interaction (t = .03, p = .971)

were not significant, the model was rerun without child sex as a moderator to further examine simple effects of the praise by CAR interaction. The interaction between parent praise and CAR was significant (b = -1.77, SE = .83, t = -2.12, p = .038, CI: -3.43 – -.10). High praise was associated with lower externalizing problems in children with high CAR (b = -4.08, SE = 2.13, t = -1.91, p = .061, CI: -8.37 – .20), but not mean or low CAR (ps>.10). There were no main effects of praise or child sex (ps>.05). The overall model was not significant, R^2 = .12, F(3, 52) = 2.47, p = .072). See Figure 3 for visualization of the interactions.

Parent Positive Emotion, CAB & Child Sex. An interaction between parent positive emotion and sex (b = 5.39, SE = 2.87, t = 1.87, p = .067 CI: .-.39 – 11.16) was examined for conditional effects which indicated that high parent positive emotion was associated with higher levels of internalizing behaviours for females (b =3.74, SE = 2.01, t = 1.87, p = .068, CI: -0.28 – 7.79) but not males (b =-1.64, SE = 2.06, t = -0.79, p = .431, CI: -5.79 – 2.51). See Figure 4 for visualization of the interaction. There was no interaction between parent positive emotion and sex (p>.10). The overall model was not significant, R^2 = .11, F(5, 48) = 1.24, p = .307.

Parent Positive Emotion, CAR & Child Sex. An interaction between parent positive emotion and child sex (b = 5.44, SE = 3.00, t = -0.97, p = .077, CI: -.60 – 11.45) was examined for conditional effects, which indicated no significant simple effects for males or females (ps>.05). There were no main effects of parent praise, CAR, or sex on children's internalizing problems (ps>.05). There was no interaction between parent praise and CAR (p>.10). The overall model was not significant, R^2 = .11, F(5, 48) = 1.20, p = .325). Given that the main effect of CAR (t = -0.56, p = .580) and the CAR by positive emotion interaction (t = 0.03, p = .973) were not significant, the model was rerun without CAR as a moderator to further examine simple effects of the positive emotion by child sex interaction. The interaction between parent positive emotion and CAR (b = -5.39, SE = 2.76, t = -1.95, p = .057, CI: -3.43 – -.10) was examined for

conditional effects which indicated that high parent positive emotion was associated with more internalizing behaviours for females (b = 3.74, SE = 1.92, t = 1.95, p = .057, CI: -.12 – 7.60) but not males (b = -1.65, SE=1.99, t = -0.83, p = .411, CI: -5.64 – 2.34). There were no main effects of parent positive emotion or child sex (ps>.05). The overall model was not significant, R^2 = .09, $F(3, 51) = 1.73$, p = .172.

Discussion

The present study examined how specific parenting behaviours are linked to preschool-aged children's internalizing and externalizing behaviours and if children's physiological activity and sex moderated this relationship. The potential moderating role of children's cardiac autonomic regulation (CAR) and cardiac autonomic balance (CAB) was of particular interest to help advance our current understanding of how the interaction of both branches of the ANS may impact child behaviour related to the early caregiving environment. Results provided some support for possible sex differences in how parenting is linked to children's behaviour problems and patterns of autonomic activity that may contribute to higher levels of parenting-linked internalizing behaviours.

Sex Differences in Parenting Effects on Children's Behaviour Problems

Consistent with the differential susceptibility theory—that is, that some children may be more sensitive to both positive and negative contexts—males had the highest level of externalizing behaviours in the context of low parental praise and the fewest externalizing behaviours in the context of high parental praise. In contrast, females had similar levels of externalizing behaviours regardless of parental praise. While this is the first study to report on sex-differences in externalizing behaviours specifically related to praise, similar findings have been reported in the literature in the context of broader dimensions of parenting. For example, lower maternal sensitivity has been linked to trajectories of externalizing behaviour from early to

middle childhood for boys but not girls (Miner & Clarke-Stewart, 2008). Similarly, decreases in positive parenting across childhood has been linked to greater externalizing behaviours, and this effect was stronger in boys (Boeldt et al., 2012).

Praise has generally been characterized as a parenting strategy to enhance children's feeling of competence and independence, and is a strong indicator of positive parenting (Dallaire et al., 2010; Hoeve et al., 2009; Mullineaux et al., 2009). In contrast, infrequent praise may fail to convey parental validation and support, inhibiting children's sense of competence and self-regulatory capacities thus contributing to greater risk of externalizing behaviours (Karreman et al., 2006; Landry et al., 2006; Swenson et al., 2016). Although negative parenting behaviours are more often characterized as risk factors for the development of externalizing problems (e.g., Calkins, 2002; Eisenberg et al. 2015), there is similar and potentially more risk associated with the absence of positive parenting behaviours (Dallaire et al., 2006; Song et al., 2018; Pettit & Bates, 1989), and this seems to be particularly relevant for male children in this sample. For example, while hostile parenting has been linked to greater risk of aggression and emotional disorders similarly among males and females, less positive parenting was associated with greater risk of emotional disorders in males only (Browne et al., 2010). However, it is important to consider that this was not a high-risk or clinical sample so we did not observe the full range of negative or more extreme parenting behaviours that may be more typical of parents receiving support services for child maltreatment concerns, for example. Results suggesting risk associated with a lack of positive parenting may more broadly reflect experiences of poverty-related stress. Indeed, there is evidence that associations between less supportive parenting and more child negative emotionality is stronger in low-income families, but reversed in high-income families (Paulussen-Hoogeboom et al., 2007). Nonetheless, results suggest the possibility that males in particular may be sensitive to parental praise, where they experience the greatest maladjustment

when praised infrequently, but benefit the most from frequent praise. While the differential susceptibility theory may apply to these findings, there are several other factors and theoretical perspectives that might also contribute to sex differences in externalizing behaviours related to parenting.

From a differential exposure perspective, sex differences in children's behaviour problems may be due to systematic variability in how parents socialize male and female children (Endendijk et al., 2017; Keenan & Shaw, 1997). For example, if parents use less positive and more negative parenting behaviours with males compared to females, sex differences in behavioural problems may be a result of varying exposure to these parenting behaviours (Rutter et al., 2003). In this sample, males were more likely than females to experience high levels of parental control and low levels of praise compared to females. It is possible that greater externalizing behaviours related to low levels of praise observed in males is reflecting systemic differences in parent socialization practices between males and females. However, studies have generally been mixed with regard to sex and gender-differentiated parenting practices, with some studies reporting more positive-supportive parenting among females while others demonstrate minimal mean-level differences (Endednijk et al., 2016; Gershoff, 2002; Leaper, 2002). An alternative explanation for these findings is that children's behaviours or characteristics may be influencing the types of parenting they receive (Sameroff, 2009).

From a transactional perspective, it is possible that externalized behaviours are less likely to evoke positive caregiving behaviours like praise. In contrast, parent may be more likely to use praise when they view their child as more regulated. While low parental praise may contribute to externalizing behaviours, it may also be true that males who are regarded as more externalizing naturally receive less parental praise. However, males and females in this sample had similarly average levels of externalizing behaviours. If viewed from a purely transactional perspective, it

does not explain why only male children who elicit less praise are more likely to be rated as higher in externalizing behaviours. Additionally, it does not necessarily explain why males also displayed the fewest externalizing behaviours in the context of high parental praise, suggesting greater sensitivity to both low and high levels of praise. Results support what has been previously observed in the literature—male children may be particularly sensitive to the risk associated with low positive parenting behaviours and, in particular, a lack of praise.

A transactional perspective may be better applied to the finding that female children had heightened levels of internalizing problems in the context of high parent positive emotion, whereas males had similar levels of internalizing behaviours regardless of parent positive emotion. Females who display characteristic internalizing behaviours (e.g., withdrawal, negative affect) may elicit more positive emotion reactions from parents (Serbin et al., 2015). It is possible that parents in this sample utilized greater emotional support strategies (e.g., reacting with more explicit positive affect) among more internalizing females in order to evoke greater positive emotion and engagement during the joint problem-solving task. On the other hand, this may reflect a sex difference in emotion socialization in which females may receive greater support for sadness/withdrawn behaviours as a way to promote greater expression of positive emotion (Brown et al., 2015; Chaplin et al., 2010).

CAR Associated with Children's Externalizing Behaviours

This study adds to a small literature on preschool-aged children's cardiac autonomic balance (CAB) and cardiac autonomic regulation (CAR) in relation to early behaviour problems. In this sample, low CAR (greater coinhibition of SNS and PNS) was associated with more externalizing problems, after controlling for the effects of parent positive emotion and child sex. Greater coinhibition reflects uncoordinated action of both the PNS and SNS in which both systems perform opposing roles. In the context of the joint problem-solving task, greater

coinhibition may reflect an ambivalent physiological response to a novel and challenging situation where the optimal level of arousal is relatively ambiguous (Giuliano et al., 2015). The task is not designed to evoke an explicit stress response, but requires active mental, physical, and social engagement. Alternatively, coinhibition may reflect PNS withdrawal to facilitate increased behavioural regulation to meet the demands of the task, paired with an insufficient SNS response that fails to promote an active behavioural response.

Theoretically, a physiological response characterized by PNS and SNS coinhibition has been suggested to promote a form of passive vigilance, where greater PNS withdrawal may contribute to poorer behaviour regulation and blunted SNS response may contribute to temperaments characterized by greater reward sensitivity, impulsivity, and stimulation-seeking behaviours (El-Sheikh et al., 2009; Raine, 2002). Opposing action of autonomic branches has been similarly identified as a vulnerability factor for externalizing problems and has been associated with greater stress exposure in other samples (El-Sheikh et al., 2009; Salomon et al., 2000). However, the types of physiological responses that function as vulnerability or protective factor are likely to vary by age and context. Most empirical evidence for associations between children's behaviour problems and the interaction of SNS and PNS activity are in the context of higher-risk environments (e.g., marital conflict) and with older children. There are likely nuanced differences that can be observed in other contexts, both in how risk becomes embedded in children's physiology and how subsequent ANS programming contributes to increased likelihood of maladjustment.

This is the first study to examine the interaction of autonomic branches in preschool children of low socioeconomic status, particularly with respect to psychopathology. Though coinhibition was linked externalizing problems in this sample, it is important to interpret these findings with some degree of caution. First, this association was incidental and was evidenced in

only one regression model, so it may not reflect the more robust associations that have been described in other studies. Second, measures of CAR included PNS reactivity but baseline SNS scores, which does not adequately capture how the SNS responded during the problem-solving task. However, previous studies have demonstrated efficacy in using PNS reactivity scores relative to baseline SNS (El-Sheikh et al., 2009; Knight et al., 2020). Further, SNS reactivity observed across a variety of laboratory tasks is typically negligible (Bush et al., 2011), so SNS reactivity during the problem-solving task employed is unlikely to be meaningfully different from observed baseline SNS activity. Nonetheless, results highlight the importance of considering concurrent patterns of sympathetic and parasympathetic responding which may reveal underlying vulnerabilities that confer risk for children's behaviour dysregulation.

Differential Susceptibility to Parent Praise: The Role of Coactivation

Individual differences in ANS activity can contribute to variability in children's response to parenting. In this sample, children with high CAR (greater coactivation of SNS and PNS) had the highest level of internalizing behaviours in the context of low parental praise but seemed to benefit the most from receiving high parental praise; that is, they displayed substantially lower internalizing problems with more frequent praise. This finding supports a differential susceptibility theory such that children who display greater coactivation may be sensitive to both positive and negative contexts.

Coactivation generally reflects an uncoordinated physiological response in which sympathetic activation leads to an increased heart rate and state of heightened arousal, while the parasympathetic branch is simultaneously engaged to lower arousal and promote greater behavioural and emotional regulation. Measurement of CAR in this study included both baseline levels of SNS and PNS reactivity during the task. High resting SNS activity may therefore reflect a trait-like state of increased arousal and vigilance, which has been previously associated with

greater internalizing symptoms in preschool-age children (Rudd et al., 2021). Greater PNS reactivity during the task may then reflect an attempt to reduce arousal and promote regulation, despite having characteristically higher levels of arousal. It may be that children in this sample who have higher trait-like SNS activation, and therefore higher vigilance, are more broadly at risk of internalizing behaviours particularly in less supportive environments, like low praise. Attempts at self-regulation via increased PNS activity, despite high arousal, may afford additional benefit in supportive contexts, like high praise, in which parents can promote increased coping and regulatory capacities. This finding is consistent with studies of older children which similarly identified coactivation as a vulnerability factor for internalizing problems, particularly in the context of increased environmental stress (e.g., marital conflict; El-Sheikh et al., 2013). This is the first study demonstrating that coactivation may confer risk in less supportive contexts, but that might additionally promote increased benefit from high support contexts.

Limitations

Although the present study provides some evidence for sex differences in parenting effects on children's early behaviour problems and underlying physiological influences, several limitations should be considered. First, the cross-sectional nature of this study limited examination of developmental trajectories during a sensitive period of development when maturation and organization of the PNS and SNS may produce important differences in behaviour over time. However, studies have demonstrated relative consistency of autonomic activity across the preschool period that generally reaches stability around age five (Alkon et al., 2011). Characteristics of the sample may also limit generalizability of findings. First, families were recruited through Head Start which services families with socioeconomic adversity. This study therefore oversampled for families living at or below the poverty line, potentially

homogenizing the sample and limiting variability across other variables of interest. Nonetheless, findings from this study are important for contextualizing how children's early caregiving environment may contribute to development of psychopathology, particularly for those experiencing socioeconomic adversity. While examining the impact of poverty-related risk on children's outcomes was unfeasible given the restricted income range of the sample, findings highlight the importance of investigating low-income contexts in which families may be more broadly experiencing risk and increased stress. Second, the sample did not have clinically-significant levels of internalizing or externalizing problems, which limits clinical implications for identifying possible risk associated with parenting and autonomic function. For example, greater externalizing problems observed in relation to low parental praise for males may not necessarily reflect a maladaptive behaviour pattern but normative variation. Associations between parenting and elevated symptoms observed in this simple may still be important for identifying potentially risky contexts related to behavioural precursors to maladaptation that may not reach clinical levels under optimal circumstances. Finally, sample size was also constrained given available data across measures of interest. In particular, only a subset of participants with task data also had physiological measures and matched PKBS data. Data loss in physiological measures is not uncommon with studies of young children for a number of reasons including refusal or discontinuation of electrodes, motion artifacts, and compliance with best-practices for acquiring heart-rate data with good signal-to-noise ratio. Additionally, it limited our ability to examine potentially important associations among different sociodemographic groups. For example, parenting practices may vary between mothers, fathers, and other primary caregivers in general and depending on the sex of the child, which has important implications for children's behavioural outcomes (Li et al., 2019; Rinaldi & Howe, 2012). Nonetheless, important interactions still emerged in the data even with a relatively small sample and more liberal test of

significance for probing possible relationships. Given the novelty of this research, particularly with measures of CAB and CAR, findings from this study at least provide avenues for further exploration that will be important for elucidating more precise and confident associations between children's early caregiving environment, autonomic function, and early behaviour problems. Findings should be interpreted with caution, particularly given the exploratory nature of this study and the small effect sizes achieved across results.

Strengths

Despite the methodological limitations, this study has a number of notable strengths. First, this study is one of few that examines parenting with increased specificity to understand which types of parenting behaviours are most, or least, associated with children's psychopathology outcomes. While most research to date has focused on broad dimensions of parenting, particularly highlighting the role of adverse caregiving, there are likely nuances in dynamic parent-child interactions that are not captured in these broad-based measures of parenting. This study provides support for increasing specificity in research, and in particular, continuing to identify aspects of more positive and supportive contexts that may also be important targets of intervention alongside parenting deficits often cited in the literature (e.g., intrusive or harsh parenting). For example, the fact that males in this sample displayed the fewest externalizing behaviours in the context of high parent praise may be important for addressing sex-differences in rates of behaviour problems.

Second, this is the first study to examine the interaction of autonomic branches among preschool children in relation to psychopathology, particularly in the context of socioeconomic risk. Research on the interplay of the PNS and SNS is considerably underdeveloped, and while there has been some shift in the field towards including these physiological measures, the state of the literature is still relatively divided, with the majority considering the role of the PNS and

SNS separately. It is possible that advancement and momentum in the field will develop as findings continue to emerge. This study provides some basis for continuing to explore the role of CAB and CAR in the development of psychopathology.

Implications and Future Directions

While studies to date have primarily focused on higher-risk family contexts marked by high conflict and adverse parenting, this study highlights the importance of understanding adaptive or lower-risk contexts that may characterize more normative early experiences. Current clinical and community-based parenting interventions often focus on deficit models which aim to correct or prevent adverse parenting to improve children's outcomes. In contrast, the present findings highlight the potential benefits of targeting positive aspects of parenting that may promote more adaptive family functioning and children's mental health. For example, encouraging or enhancing positive parenting behaviours, such as praising the child, may be a productive and efficacious model of intervention for children at risk of self-regulation deficits or early emerging mental health concerns. Strengths-based interventions (e.g., Filming Interactions to Nurture Development; Fisher et al., 2016) have received much attention as an important intervention model particularly for child who experience heightened stress and adversity in their early years (Black & Hoeft, 2015; Shonkoff et al., 2009). This study emphasizes parental praise and expression of positive emotion as behaviours that may be important for promoting children's self-regulation and positive mental health outcomes, particularly for families experiencing socioeconomic adversity.

While this research is relatively novel with regards to potential interactions with children's early environment, there are valuable avenues for future work. Early stress associated with lower financial status has the capacity to influence biological programming of physiological stress functioning that may produce downstream vulnerabilities to mental health problems. This

study provides some evidence that children's physiological function, or ability to adaptively regulate their internal physiological state, may influence their behavioural outcomes related to early parenting. For example, children who display higher levels of physiological arousal concurrent with behavioural vigilance or internalizing behaviours may benefit the most from parent praise or show reduced internalizing behaviours in high supportive contexts. It will be important from both a research and clinical perspective to further explore how children's physiological states of arousal may be linked to displays of internalizing or externalizing behaviours under varying contexts. This may provide insight on how parents can best support children based on potential vulnerabilities "under the skin" but that may be evidenced in behavioural or emotional deficits that can be targeted to improve clinical outcomes. Future work should continue to investigate possible interactions between children's early environment and patterns of autonomic activity in order to identify markers of vulnerability for dysregulated behaviour.

Conclusion

Findings from the present study provide insight into possible sex differences in how specific parenting behaviours are associated with children's early behaviour problems. In particular, male children may be more sensitive to parent praise, exhibiting more externalizing behaviours than females in the context of low parental praise but the fewest externalizing behaviours in the context of high parental praise. Additionally, results provide evidence that interactions between the PNS and SNS may moderate the association between parenting and preschool-age children's internalizing behaviours. Children who exhibit greater coactivation of the PNS and SNS displayed the lowest levels of internalizing behaviours in the context of high parental praise. This work adds to a small body of literature examining interactions between autonomic branches, which is likely to more accurately capture the complex synergistic nature of

autonomic functioning that may account for variation in children's early behaviour problems. Findings from this study additionally highlight the importance of examining psychopathology outcomes in more adaptive contexts. Much focus has been given to deficit models of child psychopathology that aim to identify risk associated with early adversity. However, identifying parenting or contextual factors that support the greatest psychological benefit are equally as important in informing possible targets of clinical intervention designed to enhance parenting for improving child outcomes.

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Table 1.

Sample Characteristics

Variables	n	Valid %
Child age (mo.)	97	
Ethnicity		
Hispanic/Latinx	13	13
Not Hispanic/Latinx	49	49
Marital status	85	
Married	38	44.7
Living with partner	19	22.4
Single	18	21.2
Divorced	4	4.7
Separated	5	6.9
Widowed	1	1.2
Annual household income		
$0 – 5000	6	71
$5000 – 10000	12	14.3
$10000 – 15000	16	19.0
$15000 – 20000	13	15.5
$20000 – 25000	14	16.7
$25000 – 30000	9	10.7
$30000 – 35000	3	3.6
$35000 – 40000	2	2.4
$40000 – 50000	4	4.8
$50000 – 70000	4	4.8
Parent Education	83	
Less than 7th grade	1	1.2
Junior high (9th grade)	5	6.0
Partial high school	23	27.7
Partial college/trade school	41	49.4
Undergraduate college	11	13.3
Graduate college	2	2.4
Relationship to child	97	
Mother	84	86.6
Father	12	12.4
Aunt	1	1.0

Table 2.

Parent Behaviour Code Examples

Behavioural Code	Verbal	Gesture
Negative Emotion Reactions	"Don't mess it up now" "You're not even trying to do this" "Break it and I won't take you to get your toy" "You're not doing it right. You're not listening." Deep sighing "Ugh"	Shakes head angrily Glares at child Crosses arms Eyebrows raised looking at child Throws hands in the air Shakes head in frustration Puts hand to head in frustration
Positive Emotion Reactions	Cheering ("yay!") Laughing Exclaiming in excitement	Smiles Waving hands happily
Praise/Encouragement	"Good job!" "You're perfect" "Yep, there you go" "Couldn't have been more perfect" "Give me high fives!" "You're like a Duplo master" "Now you do it without my help"	High five Pat on back Hugs child Claps
Controlling	"Listen to me" "Look at me now" "Stop doing that" "If you don't finish this, you don't get a treat" "They're watching you through the camera" "They know what you're doing"	Grabs child Moves child's hand to grab block
Task-Strategizing	"You're going to need two of those" "Put another one there" "Take those off" "Put the blue on top of the green"	Points to blocks/guiding child's hand Leans into table to examine model Examines child's design

Note. All examples are taken directly from coded videos

Table 3.

Descriptive Statistics of Parent Codes Informing Binary Categorization

	N	Mean	Skewness	Kurtosis	Percentiles			Binary Categorization (n)	
					25	50	75	Low	High
Negative Emotion♦	100	1.55	4.16	20.10	0.00	0.00	1.22	68	32
Positive Emotion	100	4.32	1.74	2.96	0.00	2.00	6.50	42	58
Praise	100	11.77	.65	-.07	5.18	10.00	18..25	47	53
Task Strategizing	100	59.48	.702	-.365	31.06	48.00	85.28	50	50
Control♦	100	2.38	4.36	25.48	0.00	0.00	3.00	59	41

♦Coded as low = 0, high > 0

Table 4.

Bivariate Associations (Pearson And Point-Biserial Correlations) of Key Study Constructs and Sociodemographic Variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Child age	-	-.31*	.25	.34**	.15	.02	.04	-.25	.08	-.03	.14	.06	.19	-.07
2. Marital Status	.03	-	-.40**	.10	-.03	.09	.14	.06	.02	-.08	.30	-.05	-.24	.00
3. Household Income	.06	-.26*	-	.11	.09	-.33	-.35*	-.30	.17	.12	-.10	-.01	-.09	-.06
4. Parent Education	.07	.00	.24	-	.04	.08	-.10	-.12	.15	.15	.02	.01	.04	-.08
5. Ethnicity	.31*	-.06	.36	-.15	-	.13	.21	.06	.04	.01	.19	.09	-.10	-.14
6. PKBS Internalizing	-.27	-.28	-.04	-.06	-.14	-	.75**	.12	.29	.02	-.15	-.25	.07	-.15
7. PKBS Externalizing	-.21	.11	.09	-.05	-.05	.56**	-	.15	-.13	-.03	.09	.10	.00	.03
8. Negative Emotion	-.30	-.05	-.20	-.13	-.09	.17	.35	-	.01	-.06	.18	.25	.06	.05
9. Positive Emotion	.15	-.03	-.04	.04	.09	-.26	-.39*	-.24	-	.19	-.10	-.32*	-.24	-.29
10. Praise	.27	-.05	.21	.31*	.15	-.46*	-.48*	-.40**	.35	-	.00	-.19	-.18	-.24
11. Task Strategizing	-.12	-.13	-.08	-.16	.22	-.02	-.08	-.01	.03	-.15	-	.23	-.05	.03
12. Control	-.13	-.21	-.08	-.08	-.15	.13	.32	.45**	-.25	-.44**	.32*	-	-.02	.27
13. CAB	.42**	.04	.04	-.09	-.02	-.08	-.24	.01	-.14	.00	-.01	.10	-	.14
14. CAR	-.04	-.07	.10	.24	.14	-.12	-.13	-.05	-.05	.25	.06	-.13	-.09	-

* p <.05
** p < .01

Note. Correlations for males displayed under diagonal (grey); females displayed above diagonal (white)

Table 5.

Regression Statistics

	Internalizing Problems (n =54)						Externalizing Problems (n=55)					
			CI						CI			
Regression	*b*(se)	*t*	LL	UL	F	R^2	*b*(se)	*t*	LL	UL	F	R^2
Praise & CAB					.59	.06					1.24	.11
Praise	-6.62(4.97)	-1.33	-16.61	3.37			-24.45(10.46)	6.42**	-45.46	-3.42		
CAB	.49(.99)	.50	-1.50	2.48			.04(2.07)	.02	-4.11	4.20		
Sex	-.17(2.17)	-.08	-4.54	4.20			-7.30(4.50)	-1.62	-16.34	1.74		
Praise X CAB	-.64(1.20)	-.53	-3.05	1.77			.21(2.51)	.08	-4.85	5.26		
Praise X Sex	3.42(3.09)	1.11	-2.80	9.64			11.93(6.46)	1.85*	-1.05	24.93		
Praise & CAR					1.45	.13					1.84	.16
Praise	-1.36(5.27)	-.26	-11.96	9.24			-26.58(11.48)	-2.31**	-49.55	-3.41		
CAR	.40(.63)	.63	-.87	1.67			-.81(1.38)	-.56	-3.58	1.96		
Sex	.15(2.04)	.07	-3.95	4.25			-7.19(4.31)	-1.667	-15.86	1.48		
Praise X CAR	-1.88(.98)	-1.93*	-3.85	.08			1.61(2.13)	.76	-2.68	5.90		
Praise X Sex	.12(3.30)	.04	-6.51	6.75			13.35(7.11)	1.88*	-.95	27.65		
Pos. Emotion & CAB					1.24	.11					1.49	.13
Positive emotion	-7.02(4.58)	-1.53	-16.24	2.20			-13.53(10.05)	-1.35	-33.73	6.66		
CAB	-.98(1.36)	-.72	-3.71	1.75			-3.74(2.99)	-1.25	-9.76	2.23		
Sex	-1.48(2.16)	-.68	-5.83	2.87			-5.72(4.76)	1.20	-15.29	3.85		
Pos. Emotion X CAB	1.33(1.48)	.90	-1.65	4.31			3.79(3.26)	1.16	-2.76	10.34		
Pos. Emotion X Sex	5.39(2.87)	1.87*	-.39	11.16			4.93(6.27)	.79	-7.66	17.53		
Pos. Emotion & CAR					1.20	.11					2.13	.18
Positive emotion	-7.59(4.76)	-1.60	-17.16	1.98			-17.74(9.86)	-1.80*	-37.54	2.07		
CAR	-.42(.76)	-.56	-1.96	1.11			-3.21(1.53)	-2.11**	-6.28	-.15		
Sex	-2.13(2.19)	-.97	-6.54	2.28			-8.26(4.54)	-1.82*	-17.39	.87		
Pos. Emotion X CAB	.03(.99)	-.03	--1.96	2.02			3.20(2.02)	1.58	-.88	7.26		
Pos. Emotion X Sex	5.43(3.00)	1.81*	-.60	11.48			7.44(6.22)	1.20	-5.07	19.94		

*p<.10
**p<.05
***p<.01

Figure 1.

Example PROCESS Model 2 (Double Moderation) Conceptual Diagram

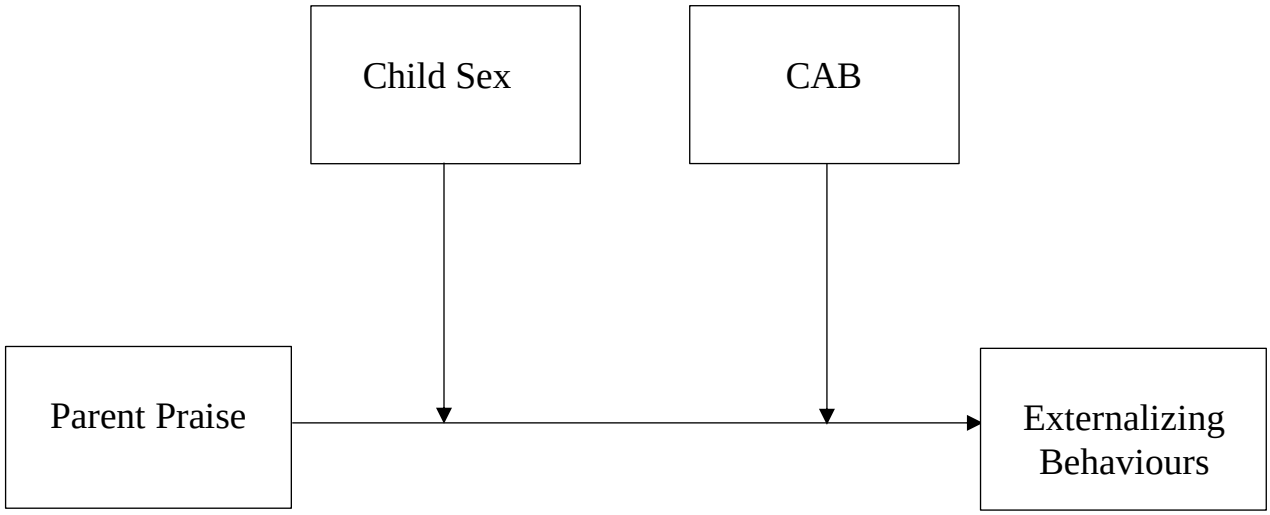

Figure 2.

Interaction between Parent Praise/Encouragement and Child Sex

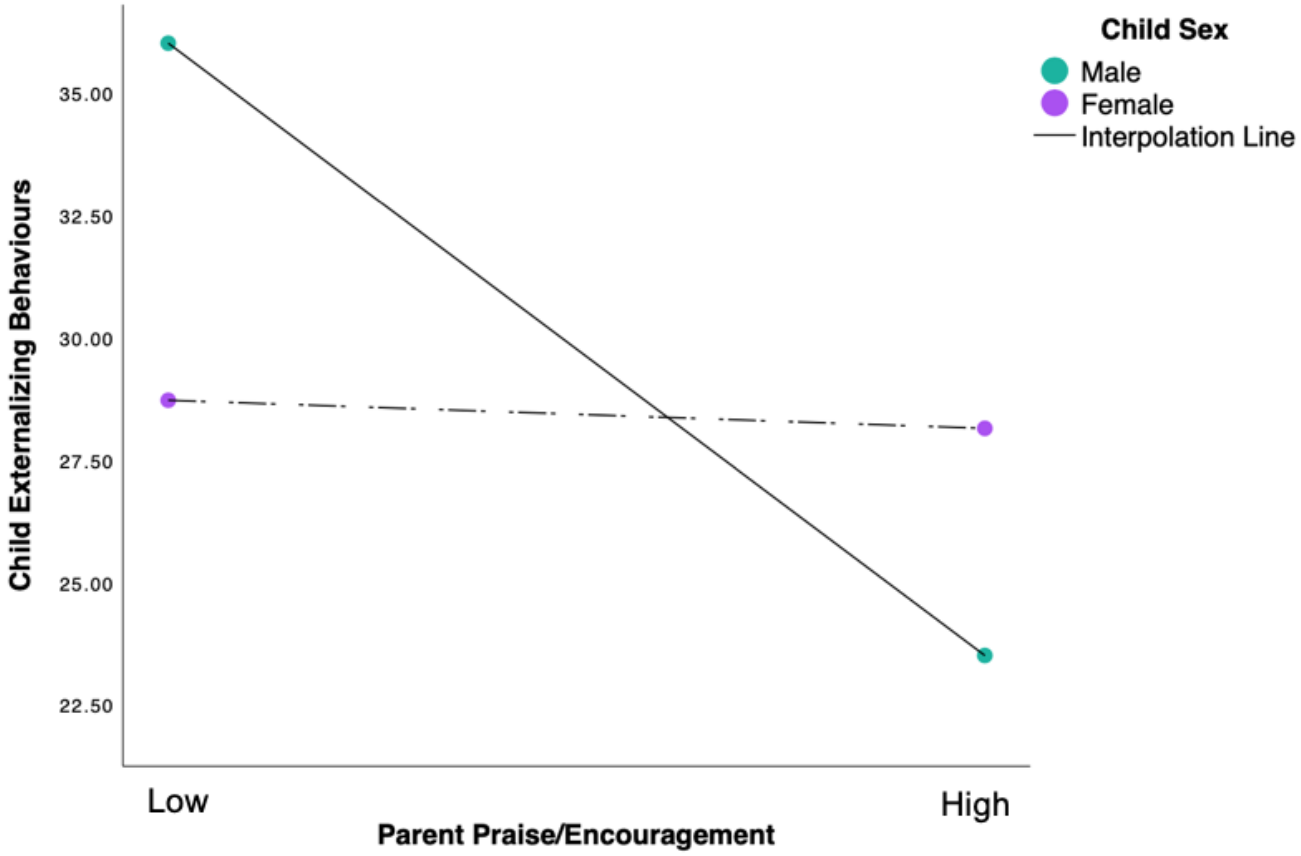

Figure 3.

Interaction Between Parent Praise/Encouragement and CAR

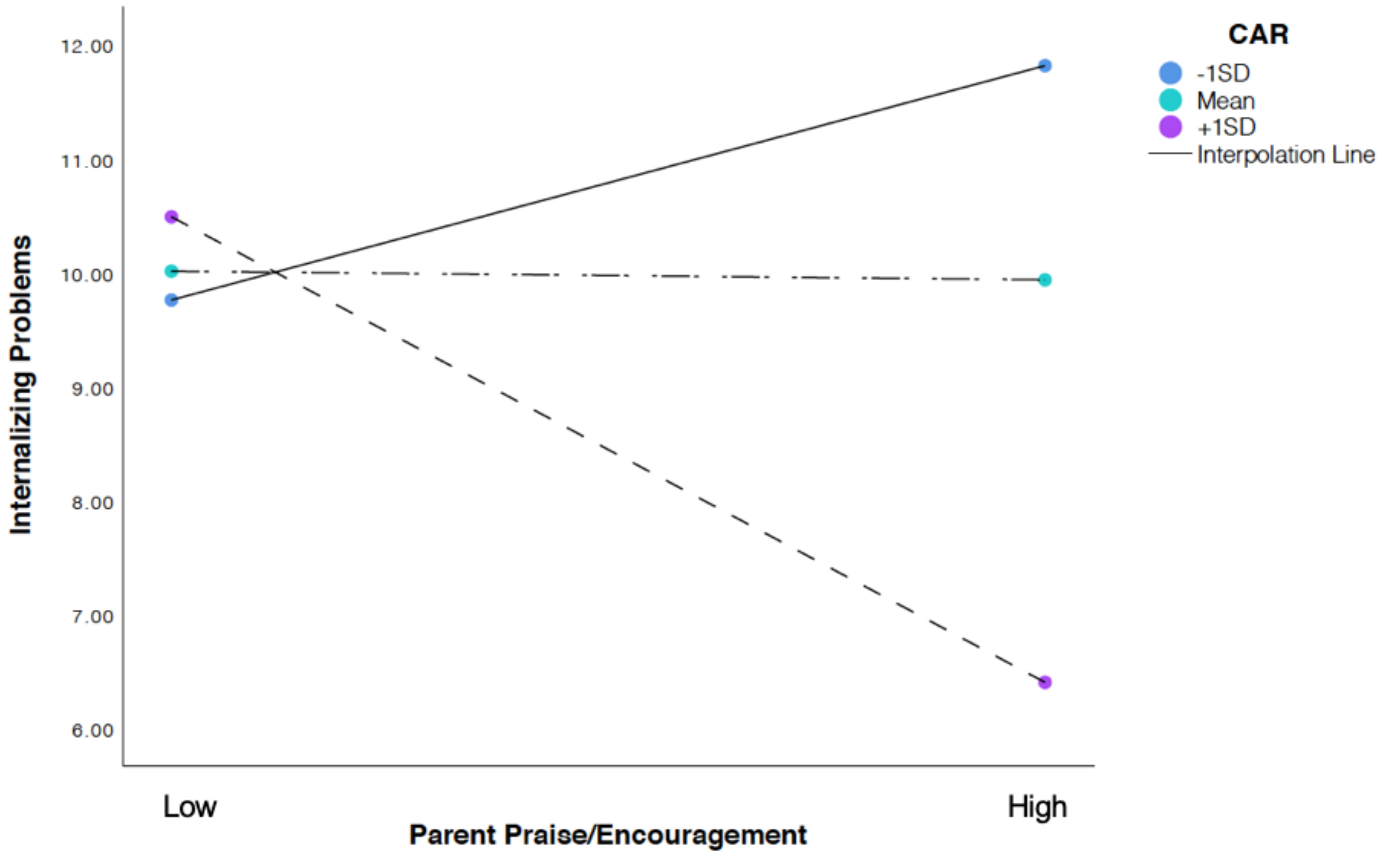

Figure 4.

Interaction Between Parent Positive Emotion and Child Sex