Exploring Pathways between Parenting Quality and Child Self-Regulation

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Declaration

I confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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Overview

The present thesis describes the results of two investigations of the association between parenting and children's self-regulation abilities.

The first paper is a systematic review and meta-analysis of the relationship between parenting quality and children's physiological reactivity to stress. Thirty-four studies associating parenting with children's cortisol reactivity to acute stressors were identified, in which an overall negative relationship between sensitive parenting and cortisol reactivity was observed. However, the literature was very heterogeneous, suggesting that there are important moderators to this relationship; few of which were identified by the analyses.

In the second paper, I present the results of a longitudinal structural equation modelling (SEM) study which explores the inter-relationships between maternal sensitivity, children's peer relationships, and a cognitive aspect of self-regulation: attentional control. The analysis is based on data collected as part of the NICHD Study of Early Child Care and Youth Development. Significant reciprocal relationships were found between maternal sensitivity and child attentional control throughout the elementary school years, and there was some evidence of reciprocal relationships between children's popularity with peers and maternal sensitivity, which were partially mediated by attentional control.

Part three is a critical appraisal of the process of carrying out the SEM study described in the second paper. It considers the advantages and disadvantages of secondary data analysis, difficulties encountered with defining complex constructs like self-regulation, and the broad clinical implications of the work.

Impact Statement

Questions about the impact of parents on children and vice versa have long held interest for researchers in psychology and other fields. The present thesis adds to the existing knowledge base through the use of large datasets (with sample sizes of 4,833 in the meta-analysis and 1,040 in the empirical paper) and sophisticated statistical techniques (meta-analysis and longitudinal SEM). This allowed for the assessment of mediation, moderation, and causal inference in the relationships between parenting and self-regulation, with greater confidence than is often the case in psychological research that relies on cross-sectional methodology and small-*n'*s.

Our findings in each paper add further weight to the well-established finding that early and concurrent caregiving during early to middle childhood has important implications for child adjustment. The results are therefore broadly supportive of early intervention programmes that aim to increase positive parenting practices, as these may improve child physiological and cognitive self-regulation.

However, results also suggest that future research would benefit from taking a multi-factorial and bi-directional approach the study of child self-regulation in order to gain a fuller picture of this aspect of development. Parenting effects were significantly, though weakly, correlated with child cortisol reactivity and attentional control, suggesting that other child, parent and/or environmental factors may be important when considering the impact of parents on self-regulation.

In addition, we found evidence for reciprocal relationships between parent and child characteristics across development, highlighting the importance of each in the prediction of child outcomes. Clinical interventions should therefore focus not just on the contributions of parents, but also the contributions of the child, and possibly, those from the peer setting. Intervention focused on only one of these factors might be less impactful than coordinated change at the level of all three, and so interventions which integrate a holistic understanding of child development are likely to be most beneficial.

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Part 1: Literature Review

Systematic Review and Meta-Analysis of the Relationship between Parenting Quality and Children's Cortisol Reactivity

ABSTRACT

Aims: In recent years, there has been a proliferation of research into the influence of early parenting on children's physiological stress regulation systems. The relationship between parenting and the activity of one such system, the HPA axis, does not appear to be straightforward, but has not yet been systematically reviewed. This systematic review and meta-analysis investigates the relationship between parenting quality and children's salivary cortisol reactivity to experimental stressors, and the potential moderators of this relationship. **Method**: A systematic search of the literature was conducted on three electronic databases (PsychINFO, Medline, EMBASE) and effect size and moderator data were extracted from eligible studies. A meta-analysis of study correlation coefficients and sub-group moderator analyses were conducted. **Results**: Thirty-four studies were included in the analysis, which found a significant but small pooled negative association between parenting behaviour and child cortisol reactivity (r = -.07), meaning that children of more sensitive parents tended to mount a smaller cortisol reaction to challenge. This effect was moderated by the index used to quantify cortisol responses, the quality of the coding scheme used to measure parenting, and the success of the study procedures in eliciting a mean cortisol increase amongst its participants. **Conclusions**: Results suggest that parenting is only weakly associated with cortisol reactivity, and that the effect is not robust. Many of the moderators included in this analysis were unable to explain the heterogeneity in study effect sizes and direction across studies. Methodological factors appeared to be most important in explaining between-study variability. Individual differences in child cortisol reactivity may be best understood by considering parenting as one of a number of potential factors in the development of the HPA axis, or by using more precise methods for measuring child physiological function.

1.0 INTRODUCTION

Throughout their development, most children will face daily psychological and physical stressors. Examples might include being vaccinated, temporary maternal separation, or navigating the social environment at school or nursery. Adaptive responding to these kinds of acute challenge[1] is essential for normative everyday functioning, allowing a child to optimise his or her resources to meet the particular demands of the environment (Fox, Hane, & Perez-Edgar, 2006). A growing literature suggests that a child's early environment plays an important role in shaping the body's on-going response to challenge, and that subsequently, differences in physiological stress systems may be one mechanism by which later psychological and physical health problems develop (Ha & Granger, 2016; Luecken & Lemery, 2004). Understanding which aspects of early experience impact the human stress response, and under which conditions, is therefore an increasingly important goal for researchers interested in developmental risk and resilience. In this systematic review and meta-analysis, the association between one aspect of early experience, parenting quality, and children's acute physiological stress responses, is explored.

1.1 The HPA Axis

The hypothalamic pituitary adrenal (HPA) axis, a neuroendocrine system comprised of the hypothalamus, pituitary gland and adrenal gland, is considered a central regulator of the body's response to stress (Lovallo & Thomas, 2000). Normatively, HPA action promotes a working balance in the body's physiological and cognitive/affective systems which allows for adaptive responding to shifting, unpredictable, and novel environmental demands (Dickerson & Kemeny, 2004; Gunnar & Herrera, 2013). The end product of the axis, the hormone cortisol, is secreted in a diurnal pattern throughout the day ('basal cortisol') and it

[1] I will be using the terms 'stressor' and 'challenge' interchangeably to mean an internal or external event which disrupts psychological and physiological equilibrium (McEwan & Stellar, 1993).

is also released in response to external threat ('reactive cortisol'), which helps the body to mount a 'fight or flight' response through its influence on metabolic, cardiovascular, immune, and central nervous systems (Fox et al., 2006; Shields, Bonner, & Moons, 2015). Cortisol is then down-regulated through a negative feedback loop once environmental challenges have been met, returning the system to homeostatic balance (de Kloet, Oitzl, & Joels, 1999). The association between cortisol and functioning has been conceptualised as an inverted U-shaped curve, whereby both very low or very high basal cortisol, or hyper- or hypo-reactive cortisol responses to a discrete stressor, appear to impede functioning, but moderate basal levels and flexible responding to challenge are considered beneficial (Sapolsky, 1997).

However, the general pattern of functioning of the HPA axis seems to vary by individual, which has the potential to impact the management of both acute stress experiences, and longer-term coping and development (Gunnar & Vasquez, 2006). Children's experiences with environmental stress may be one way in which differences in HPA function occur. Whilst exposure to mild to moderate stress in early life can promote resilience and more efficient regulation of the HPA axis (de Kloet, 1991), evidence from human and animal populations has suggested that prolonged and repeated experiences with moderate to severe stress often confers enduring vulnerabilities (e.g. see Gunnar & Quevedo, 2007). Chronic environmental stress may lead to developmental changes in the HPA axis, leading to both hyper- and/or hypo-arousal of the axis over time as the system adapts to repeated activations (Ruttle, Serbin, Stack, Schwartzman, & Shirtcliff, 2011). The severity and type of alteration to the functioning of the axis seems to depend on various factors, including the developmental timing of, amount, and type of early life stress experienced (such as maternal mental health problems, maltreatment, neglect or difficulties in family functioning; Essex, Armstrong, Burk, Goldsmith, & Boyce, 2011), as well as other contextual risk or protective factors, such as the child's temperament (Luecken & Lemery, 2004).

Long-term alterations to normal HPA activity are a feature of both the etiology and expression of a number of different physical and psychological disorders, leading researchers to theorise that HPA axis dysregulation is an important domain-general developmental risk factor (Gunnar & Vasquez, 2006). Cortisol has been shown to affect the general functioning of emotion, memory and higher-order cognitive systems (Shields et al., 2015; Thompson, Morgan, Jurado, & Gunnar, 2015). Perhaps as a result of this, increased cortisol reactivity in children has been associated with internalising difficulties (e.g. Laurent, Gilliam, Wright, & Fisher, 2015), and blunted cortisol responses are prevalent in those with externalising difficulties (e.g. Susman, 2006).

Some longitudinal studies have also shown that abnormal cortisol in childhood predicts later problems. Granger and colleagues (Granger, Weisz, McCracken, Ikeda, & Douglas, 1996) found that greater cortisol reactivity to a laboratory 'conflict' paradigm predicted greater internalising symptoms measured six months later in clinic-referred children, whilst, Essex and colleagues (Essex, Klein, Cho, & Kalin, 2002; Smider, et al., 2002) found that children with high basal cortisol at 4.5 years of age were more likely to display internalising and externalising behaviours one to two years later (see also Shirtcliff & Essex, 2008). Complementary to these findings, there is some evidence that intervention to normalise children's HPA function following experiences of chronic stress, results in concurrent behavioural difficulties also improving (e.g. Fisher, Gunnar, Dozier, Bruce, & Pears, 2006). This literature has therefore highlighted the importance of understanding the factors influencing normal and abnormal development of the HPA system for the prevention of, and intervention for, various stress-related pathologies.

1.2 Parenting and Cortisol

Infancy and early childhood are thought to be a sensitive period for the development of the HPA axis, which is present but not fully developed at birth (Loman & Gunnar, 2010). During this period, the parent-child relationship has been posited as the most important environmental influence on individual differences in HPA function and development (Gunnar & Donzella, 2002). The quality of this relationship has been subject to extensive investigation over years of developmental research, where it has been operationalised in a wide variety of ways (De Wolff & van IJzendoorn, 1997). In general, measures of high quality caregiving tend to assess the parent's ability to perceive, interpret, and respond promptly and appropriately to their child's signals, such that his or her needs are met (e.g. Ainsworth, Bell & Stayton's (1974) 'maternal sensitivity'). A vast body of literature attests to the important role of early caregiving for multiple child cognitive, social and emotional outcomes (e.g. Ainsworth et al., 1974; Bornstein & Tamis-LeMonda, 1997; De Wolff & Van IJzendoorn, 1997; Domitrovich & Bierman, 2001; Eisenberg, Cumberland & Spinrad, 1998; Rubin & Burgess, 2002), and its continued influence on adjustment into adulthood (Raby, Roisman, Fraley, & Simpson, 2015). It therefore follows that parenting quality has been of special interest in investigations of the development of children's stress regulation also.

The mechanisms through which parenting may exert an effect on the HPA axis are not yet fully delineated (Hostinar & Gunnar, 2013). One hypothesis is that prolonged experience with non-responsive, insensitive or harmful parenting may act as a chronic environmental stressor, and therefore directly affect cortisol regulation (Ha & Granger, 2016; Tarullo & Gunnar, 2006). Maternal separation, in and of itself, is a robust physiological stressor in both animal (rodent, primate) and human infants (Gunnar, Larson, Hertsgaard, Harris, & Broderson, 1992; Moriceau & Sullivan, 2005). Further evidence comes from studies of children who have experienced long-term disruptions in caregiving through parental loss or maltreatment. This literature generally suggests that children raised in institutions or placed in foster care develop deviations to the normal diurnal rhythm of cortisol and blunted responding to acute stressors (e.g. see Tarullo & Gunnar, 2006). Parenting appears to be a key aspect of the impact of these environments on the HPA axis, as its functioning can be normalised with interventions to improve foster parent sensitivity or with placement moves to high quality caregiving environments, provided this happens early enough (e.g. van Andel, Jansen, Grietens, Knorth, & van der Gaag, 2014; McLaughlin et al., 2015). Even less extreme deviations in parenting quality can cause stress: non-responsive and non-contingent parenting practices imply that parents either fail to meet the child's needs or intrude on his or her actions (Albers, Riksen-Walraven, Sweep, & de Weerth, 2008). In this case, *elevations* in children's basal and reactive cortisol may be expected as a result of the chronic experience of moderate stress (Tarullo & Gunnar, 2006).

When not acting as a direct stressor, there are other mechanisms by which individual differences in parenting quality may also affect the developing HPA axis. Parenting quality is thought to shape healthy stress responses by promoting synaptic growth in diffuse areas of the brain associated with HPA activity, such as the hippocampus and amygdala (e.g. see Schore, 1996, 2001; Susman, 2006). Similarly, we know that sensitive parenting leads to benefits in diffuse child outcomes, such as coping styles or cognitive/affective self-regulation (e.g. Luecken & Lemery, 2004) which may mediate the child's physiological reaction to a stressor. It has also been suggested that sensitive parenting is an important buffer against the impact of other potential environmental stressors. Loman & Gunnar (2010) have proposed that under normal circumstances the HPA axis has a special period of low responsivity over the first year of life, perhaps in order to protect the maturing stress system from the toxic effects of heightened cortisol. They posit that the parent-child relationship facilitates this period by helping to regulate the child's physiological response to stress (Gunnar & Donzella, 2002). For example, in one study, Gunnar and colleagues (1992) have shown that infants' cortisol responses to maternal separation could be attenuated by the presence of a sensitive, responsive babysitter (and not one who ignored the baby), but that infants who were not separated from their mothers showed no cortisol elevation at all, regardless of whether the mother played continuously with her infant, or responded only to his or her distress. In very young children, parents may need to be present for stress buffering to work, but there is evidence that for older children this need not be the case (Hostinar & Gunnar, 2013).

1.3 Difficulties in Evaluating the Relationship between Parenting and Cortisol

Evidence across a range of child populations under situations of varying stress, has provided some support for the idea that higher quality parenting is associated with lower child sensitivity to stress, as represented by smaller child cortisol reactions to acute laboratory stressors (e.g. see Gunnar & Quevedo, 2007). In these investigations, salivary cortisol is typically sampled at 'baseline' prior to the presentation of a stress provocation task, and then between 20 and 30 minutes afterward to capture the typical peak in cortisol response (Adam, Klimes-Dougan & Gunnar, 2007). The difference between the two values represents the cortisol reaction to the stressor.

Although much of this literature is cross-sectional, emerging longitudinal and intervention evidence supports the naturalistic observations. A large study of over 1000 infants found that 'maternal engagement' measured at seven months, was associated with lower basal cortisol, and less reactivity to tasks intended to induce fear and frustration at fifteen months (Blair et al., 2008), although engagement was also associated with *greater* reactivity to the same tasks at seven months. Whilst Fearon and colleagues (2017) found that maternal insensitivity measured in infancy was associated with later heightened cortisol reactivity to a social stress task in adolescence, though only for female participants. Further strong evidence comes from two randomised controlled trials of interventions designed to increase parenting quality, which have normalised basal and diurnal cortisol patterns in child clinical samples (Bakermans-Kranenburg, van IJzendoorn, Mesman, Alink, & Juffer, 2008; Bernard, Dozier, Bick, & Gordon, 2015).

However, as these examples demonstrate, despite strong theoretical assertions regarding the role of better parenting quality for reducing children's cortisol reactivity, and a general acceptance of this idea amongst many researchers, the evidence is far from equivocal. The degree to which the relationship between parenting and child cortisol holds true, and under which circumstances, is therefore not yet clear, and particularly for investigations of child responses in the context of acute challenge (e.g. see Atkinson, Jamieson, Khoury, Ludmer, & Gonzalez, 2016). Whilst some studies have found a relationship between parenting quality and child cortisol reactivity, there are a number that have found no such association. Furthermore, amongst studies in which there is a significant relationship, individual studies, and individual children, seem to vary in whether they show increasing, decreasing, or no cortisol response to challenge as a function of parental sensitivity.

These disparities have led to some criticism of the wide variability in methodology and design across child cortisol studies, which makes cross-study comparisons difficult (e.g. Atkinson et al., 2016; Dickerson & Kemeny, 2004). One difference concerns the measurement of the cortisol reaction. A recent review found there to be fifteen different indices of salivary cortisol used in the literature: all representing either basal or reactive cortisol (Khoury et al., 2015). Not only does this potentially lead to confusion when comparing study results, but Atkinson and colleagues (2016) also contend that, in fact, most of these indices do not adequately represent, or capture, the pattern of robust response and then recovery characteristic of a healthy cortisol response to stress. The measurement index used may therefore influence study results.

Likewise, there are concerns about the range and quality of paradigms used to elicit stress responses. Two systematic reviews of the literature found that many of the stressors used do not routinely elicit mean cortisol increases for groups of children on average (Gunnar, Talge, & Herrera, 2009; Jansen, Beijers, Riksen-Walraven, & de Weerth, 2010). This may be because laboratory tasks are too mildly stressful to elicit a response in any but the most hyper-responsive children (Gunnar et al., 2009), which would be expected if high quality parenting is hypothesised to successfully buffer children from responding to mild daily stress (Gunnar & Hostinar, 2015). The evidence showed that most children under three months of age mount cortisol responses to varied stressors, but reactivity then steadily decreases through to 24 months. For children aged two to five years, hardly any paradigm used in the literature successfully elicited mean cortisol reactions across study samples (Gunnar et al., 2009), potentially confounding attempts to study individual differences in cortisol *reactivity*. The paradigms most reliably able to elicit cortisol seem to involve physically painful stimuli or social evaluative threat, and the least successful aim to induce fear or frustration. Though there may be an interaction between the type of stressor and age of the child (Jansen et al., 2010).

Other reasons for disparities in the literature may relate to definitions and measurements of parenting quality (Provenzi, Giusti, & Montirosso, 2016). The lack of agreement about how parenting quality can be conceptualised has been shown to influence effect sizes in previous meta-analyses of child outcomes (e.g. De Wolff & van IJzendoorn, 1997). Differences may include the types of behavioural qualities measured, as well as whether parenting quality is operationalised primarily in terms of the parent’s behaviour, or measures synchronous mother-infant interactions which also code the child’s (Thompson et al., 2015). There is also evidence that the context of parenting measurement can have important implications: Fearon and colleagues (2017) found that maternal insensitivity was only related to child cortisol reactivity when measured during feeding and not during free play. In addition, as parenting to infant distress as opposed to non-distress has also been found to more strongly relate to child outcomes in some recent studies

(Leerkes, Blankson, & O'Brien, 2009), this may have implications for researcher's decisions to measure parenting independently of, or together with, a stressor task (which is presumably a context of child distress). Whilst other general aspects of study quality may also be expected to contribute to variability in findings, including the validity, reliability and standardisation of tasks and measures used, and particularly, controls against the confounding of cortisol measurement. There are numerous ways in which cortisol measures can be biased, including through variation in the time of day of sampling, the timing of post-stressor collection, or through differences in sampling procedures (e.g. see Hansen, Garde & Persson, 2008), and most studies fail to control for all of these factors.

Finally, evidence suggests that between- and within-study population individual differences also affect HPA functioning, and this may interact with the parenting context to various effects. Examples of moderators so far identified in some studies are child gender (Fearon et al., 2017; Sethre-Hofstad, Stansbury & Rice, 2002), temperament (Kertes et al., 2009), birth weight (Brummelte et al., 2011), experience of a recent traumatic event (Jaffee et al., 2015), and maternal mental health problems (Dougherty, Tolep, Smith & Rose, 2013). Some of these influences, particularly if chronically stressful, may alter children's basal and reactive cortisol patterns such that individual children and individual studies may include children starting from very different cortisol 'baselines'. Therefore individual cortisol responses of such populations may manifest quite differently (Hostinar & Gunnar, 2013). For example, Hunter and colleagues (Hunter, Minnis, & Wilson, 2011) reviewed studies of child cortisol in adverse contexts, including low socio-economic environments, maternal stress, and pre-natal psychoactive substance exposure. They found that baseline and reactive cortisol was heightened for children in the majority of studies, though a smaller number reported decreased baseline and reactive cortisol in contexts of adversity, and a few others found no effect.

1.4 Aims of the Present Review

Therefore, whilst there has been much prior work dedicated to investigating parental influences on the developing HPA-axis, including a number of integrative reviews of the theoretical, animal and human literature (e.g. Gunnar & Quevedo, 2007; Hostinar & Gunnar, 2013), there are still unanswered questions about the link between these variables. Whilst it is generally asserted that parenting quality is a key process in ensuring normative stress responses in children, our preliminary survey of the extant literature suggests that support for this idea is not consistent or conclusive. As the relationship between parenting quality and cortisol reactivity has yet to be systematically explored, the true extent to which study results vary, or to which that variance is attributable to methodological dissimilarities and/or specific population-based moderators, is not yet known.

The present review consequently aimed to systematically review and summarise the strength and direction of the relationship between parenting quality and children's cortisol reactivity to laboratory stressors, using meta-analytic techniques. Importantly, this technique will also allow us to statistically investigate some of the potential moderators of this relationship as discussed in the previous section. We focus on studies of children in early- to mid-childhood as this is an important developmental period for both the stress system and other child outcomes which are thought to be influenced by parenting quality, perhaps due to increased neurobiological plasticity during this period (e.g. Gunnar et al., 2009; Thompson et al., 2015). Moreover, scoping searches suggest that the majority of the literature is focused within this age range.[2]

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[2] In contrast, there is evidence of increased basal cortisol functioning in adolescence which leads to naturally higher cortisol reactivity than in earlier years (Jansen et al., 2010), and the influences of peers on HPA regulation may become more important (Hostinar & Gunnar, 2013). Hence this review focuses only on the pre-adolescent phase.

Based on the literature already summarised, it was hypothesised that:

1) A combined negative correlation would be observed between parenting quality and child cortisol reactivity across studies (meaning that higher quality parenting would be significantly associated with lesser child cortisol reactivity);
2) Which would be significantly moderated by:
    a. the child’s age (where a smaller effect was expected amongst older children; Gunnar et al., 2009; Jansen et al., 2010);
    b. the type of stressor task (with stronger associations expected for physical pain stressors, and lesser associations for challenges involving emotion provocation; Gunnar et al., 2009); and,
    c. the ‘success’ of the stressor task (with stronger associations expected for studies using stress tasks which were successful in eliciting a mean significant increase in cortisol in participants).
3) In addition, the following potential moderators were explored in the analysis, where existing evidence was mixed or insufficient for predicting the nature of the impact on the relationship between parenting quality and child cortisol reactivity:
    d. child or parent adversity;
    e. the index of cortisol measurement;
    f. the parenting construct measured; and,
    g. the methodological quality of the study (including procedures used for collecting and analysing cortisol samples, and measuring parenting quality).

2.0 METHODS

2.1 Search Strategy

To identify articles for the present review, both systematic database searches and hand searches of the literature were completed. A search of the electronic databases, EMBASE, Medline, and PsycINFO, was conducted first, on 5 August 2017. Following this, the reference lists of narrative and systematic reviews of child cortisol reactivity were hand searched for any further papers which might meet search criteria. These reviews were identified via the database search and from the reference lists of included articles.

Database searches were specified for all papers published in peer-reviewed journals, from the start of records until the date of the search, which were written in English, and which tested human participants. To maximise both the sensitivity and specificity of the records returned, search terms were selected to represent (1) a broad range of parenting constructs (based on prior meta-analyses of parenting behaviours by Bilgin & Wolke, 2015, and De Wolff & van IJzendoorn, 1997), (2) the measurement of cortisol; and (3) the target age range (children between 0 and 11 years of age).

Terms in each of these categories were first entered individually as ‘keyword’ searches of study abstracts and titles, and were then expanded as ‘subject heading’ searches. EMBASE, Medline and PsycINFO each catalogue articles using different ‘subject headings’, which resulted in the use of different subject heading terms within each database, though these were based on the same initial keywords (final search terms are listed in Table 1). Individual keywords and expanded subject heading searches were combined with the operator ‘OR’ to maximise the amount of returned papers. Searches between each category (parenting, cortisol, children) were then combined with the operator ‘AND’ in order to select articles that contained all three of the domains of interest to the present review.

Table 1. Electronic Search Terms

Category	Search type	Database	Search terms applied
Parenting	Keyword	All	childrearing or mothering or mother child interaction* or mother child relation* or parent child interaction* or parent child relation* or mother infant interaction* or parent infant interaction* or parenting or responsiveness or maternal adj sensitivity or parent* adj1 sensitiv* or caregiving or synchrony or attune* or mutuality;
	Subject heading	EMBASE	exp maternal behavior or exp child parent relation or exp mother child relation.
		Medline	exp maternal behavior or exp mother-child relations or parent-child relations.
		PsycINFO	exp mother child relations or exp parenting style or exp parenting .
Cortisol	Keyword	All	cortisol or adrenocorti* or neuroendocrin* or HPA* or HPA adj axis or hypothalamic-pituitary-adren* or stress adj1 reacti* or allosta*;
	Subject heading	EMBASE	exp hydrocortisone.
		Medline	exp pituitary-adrenal system or exp hydrocortisone.
		PsycINFO	exp stress reactions or exp hydrocortisone or exp hypothalamic pituitary adrenal axis.
Children	Keyword	All	child* or infant* or baby* or babies or toddler*.

Note. Initial scoping searches using the above keywords revealed that there was a high level of sensitivity but low specificity in the search, with numerous irrelevant papers returned in response to the keywords 'sensitivity', 'stress' and 'axis.' Therefore, the positional operator *adj* was used to locate only references in which these keywords were adjacent to relevant terms: maternal/parental sensitivity, stress reactivity, and HPA axis. * allows searching for variant spellings and plurals of the same terms. *exp* represents an expanded subject heading search.

2.2 Inclusion and Exclusion Criteria

In order to systematically investigate both the overall relationship between parenting and children's cortisol reactivity, and potential moderators of this relationship, a fairly liberal range of studies were included in the present review. In general, studies were included if they measured (1) observed parent behavioural quality, and (2) children's salivary cortisol, (3) in response to a physical or psychological challenge (i.e. cortisol was assessed prior to and after a 'stressor' task). Studies also had to include enough statistical information, either as published or after contacting their authors, in order to allow for the computation of an effect size for the relationship between parenting quality and children's cortisol reactivity. It follows from these criteria that articles reporting on cortisol measured in urine or hair samples, or as part of a combined physiological measure; or which reported on the *amount* of parenting behaviour, without reference to the *quality* of that behaviour, were not included. In addition, for this review, observational parenting measures were stipulated as they are less prone to bias than self- or child-report measures (Bailey, DeOliveira, Wolfe, Evans, & Hartwick, 2012), however studies reporting on composite measures of both observed and self-reported parenting were included.

Due to our interest in natural rather than experimental variations in parenting quality, studies which experimentally influenced parenting behavior through an intervention were not included. However, data were used if relevant effect sizes for non-intervention control groups were provided or available after contacting study authors (e.g. Mörelius, Örtenstrand, Theodorsson, & Frostell, 2015). Finally, and in order to increase the validity of cortisol comparisons across the included studies, study participants (children) should not have experienced severe neglect, loss or maltreatment (e.g. parental bereavement, fostered, adopted or abused populations). There is evidence of dampened basal and reactive cortisol secretion in children who have experienced maltreatment, deprivation and/or privation, making comparison with majority non-maltreated samples in the literature difficult (e.g. Essex et al., 2011).

2.3 Data Extraction

2.3.1 Coding

According to the aims of the present review, potential moderators were identified and coded amongst the broad range of included study populations, methodologies and parenting domains in order to highlight possible causes of heterogeneity in effect size. Potential moderators were assessed because there was a theoretical reason to believe a moderating effect on the relationship between parenting quality and children's reactive cortisol may be significant based on the extant literature. They comprised aspects of each study's: (1) sample characteristics; (2) parenting quality assessment; (3) cortisol measurement; and (4) methodological quality. A full list of coded moderator variables is given in Table 2.

Sample Characteristics. Child age has been shown to be an important correlate of cortisol reactivity (e.g. Jansen et al., 2010) and therefore, for each study the mean age of the child sample was coded into the following categories: 0 - 3.4 months, 3.5 – 6.4 months, 6.5 -2.4m, or 2.5 to 11 years. These categories were based on current theoretical and empirical understandings of the differential pattern of cortisol response as the HPA-axis develops (e.g. Gunnar et al., 2009; Jansen et al., 2010; Thompson et al., 2015).

In addition, to capture differences in the presence of chronic or contextual stressors in different study samples, parent and child 'at-risk' status was coded. As in a previous review of the impact of contextual risk factors on children's cortisol (Hunter et al., 2011), risk was coded simply as 'present' or 'absent.' Risk was considered present if an environmental or physiological context which could influence the development of the HPA axis was present in at least 40% of the participants. For parents examples of 'risk' included low Socio-Economic Status (SES), teenage parenthood, drug use, and samples that had been recruited due to clinical or social services involvement (e.g. due to parent mental health difficulties). For children, risk factors included being born prematurely, or at low birth weight.

Characteristics of the Parenting Measurement. A wide range of instruments measuring various domains of parenting quality were used across the included studies. Due to the high level of heterogeneity, it was necessary to simply code categories of 'positive' or 'negative' parenting constructs, or studies which combined 'both' types of measure, in order to carry out moderator analyses. In addition, as some conceptualisations of parenting quality include explicit recognition of the role of the infant in the parent-child interaction by coding the child's behaviour as well as the parent's (e.g. Mother-Infant Synchrony (Isabella, Belsky, & von Eye, 1989)), a moderator variable was created to distinguish studies using dyadic 'parent-child measures', as opposed to standard parenting observations.

Characteristics of the Cortisol Measurement. The type of activity used in each study to induce a stress reaction was coded based on previous meta-analyses of child cortisol reactivity by Gunnar and colleagues (2009) and Jansen and colleagues (2010). The following types of task were identified:

(1) those designed to elicit fear, including the presence of strange events or people;

(2) those designed to elicit anger or frustration, including physical restraint, the Still Face Paradigm (SFP; Tronick, Als, Adamson, Wise, & Brazelton, 1978), or tasks involving rigged failure;

(3) those designed to threaten or challenge social relationships, including tasks primarily involving maternal separation, parent-child conflict or interaction, peer interactions or social evaluation;

(4) mild physical stressors, including handling, and bathing;

(5) pain stressors, such as inoculations; and,

(6) any other tasks.

If stressors included elements of two categories, judgment was used as to which would likely be the most stressful element. An example of this would be the use of multiple 'emotional elicitation' challenges from the Laboratory Temperament Assessment Battery (LabTAB; Goldsmith, Reilly, Lemery, Longley, & Prescott, 1999) designed to frustrate *and* frighten children.

Table 2. List of Moderators Considered in the Meta-Analysis

Moderator	Categories
Child age	0m – 3.4m 3.5m – 6.4m 6.5m – 2.4y 2.5y – 11y
Parent risk	No risk Risk
Child risk	No risk Risk
Parenting construct	Positive parenting Negative parenting Both positive & negative
Parent-child measure	Parent only measure Parent & child measure
Stressor task type	Fear Frustration Relational Mild physical Pain
Stressor task success	Successful Unsuccessful
Cortisol measurement index[a]	AUCi Slope Percent change Reactivity/Peak reactivity T2 value
Parenting measure	Well validated Study specific
Independent parenting & cortisol measurements	Independent assessments Interdependent assessments
Cortisol confounders	All controlled Some controlled

a. AUCi = area under the curve with respect to increase [[(post-challenge cortisol value 1 + baseline value)/2] x time] + [[(post-challenge value 2 + post-challenge value 1)/2] x time] – [baseline value x (time + time)]; Slope = slope of the line between baseline and post-challenge cortisol values; Percent change = percent change between baseline and post-challenge cortisol values; Reactivity = change in cortisol between baseline and post-challenge values; Peak reactivity = change in cortisol between baseline and peak (post –challenge) values; T2 value = post-challenge cortisol value.

A concern voiced in prior reviews is that many tasks intended to elicit a cortisol response do not actually do so (e.g. Gunnar et al., 2009). The 'effectiveness' of a task in eliciting cortisol is likely to directly impact the estimation of its correlation with parenting. Therefore for this analysis, a stressor task was considered to have been 'successful' if a study reported a mean significant increase in cortisol in the sample as a whole between pre- and post-challenge measurements.

Finally, the way in which cortisol reactivity was measured was also coded. As previously noted, cortisol reactivity has been represented by numerous different measurement indices in the literature. It has been argued that this makes comparison between different studies unreliable (Atkinson et al., 2016) though some indices are seemingly equivocal and therefore comparable (see Khoury et al., 2015). We coded the index used to assess cortisol response according to definitions by Khoury and colleagues (2015), as outlined in Table 2.

Study Quality. The quality of the measurement of key variables in the included studies was hypothesised to affect the strength of effect size reported. Firstly, we considered whether the assessment of parenting was conducted independently, or in tandem with, the stressor intended to elicit cortisol. Measurement of parenting concurrently with a 'stressor' task introduces the potential for bias given that parents may either cause additional stress or directly buffer against it (e.g. Gunnar et al., 1992). On the other hand, parenting to distress situations has been more predictive of child outcomes in other areas of developmental psychology (e.g. Leerkes et al., 2009), so parenting measured during a stress task may be more strongly associated with child cortisol reactivity. Whether studies used well-validated or study-specific coding schemes to measure parenting quality was also recorded.

Finally, concerns about bias introduced in the measurement of cortisol were addressed with the creation of a variable capturing a number of potential sources of confounding. Studies were assessed on the following criteria, based on recommendations for the reliable measure of cortisol by Hansen and colleagues (2008). Studies needed to meet all six criteria in order to be considered at low risk of confounding[3]:

(1) the sampling time for cortisol should be standardised such that all samples were collected at the same time of day, or sampling time was controlled for in the analysis;

(2) samples were taken at the same time of year;

(3) eating was controlled for 2 hours before measurement;

(4) same or comparable techniques were used to assess and collect cortisol samples;

(5) samples were stored at -20°C or lower; and

(6) there was acceptable reliability in the measurement, such that inter- and intra-coefficients of variability in cortisol assays were less than 15% and 10% respectively (Salimetrics; 2018).

2.3.2 Effect size computation

Effect sizes for the present meta-analysis were correlation coefficients, representing the strength and direction of the association between parenting quality and children's cortisol reactivity. Directly reported correlation coefficients were available in 25 of the included studies. Correlations involving indices of cortisol *reactivity* were preferred over simple post-task cortisol measures (T2 values) because measures of cortisol *change* better reflect the aims of the present review. However, correlation coefficients in general were preferred over other statistics if multiple were available for the same effect, e.g. correlations and a hierarchical linear model (e.g. Martinez-Torteya et al., 2014).

Where correlation coefficients were not reported, other pertinent data were extracted so that an effect size could be computed. In two studies, group means and

[3] Two additional criteria suggested by Hansen and colleagues (2008) were not used due to (a) a lack of relevance for the population of this meta-analysis (control of exercise before sampling) and (b) less evidence as a potential source of bias (control of medication use).

standard deviations were extracted because parenting quality had been reported as a categorical variable (Sethre-Hofstad et al., 2002; van Bakel & Riksen-Walraven, 2008). In three studies where group means and standard deviations were not reported, an effect size was estimated using raw data as reported graphically (Azar, Paquette, Zoccolillo, Baltzer, & Tremblay, 2007; Crockett, Holmes, Granger, & Lyons-Ruth, 2013; Grant, McMahon, Austin, Reilly, Leader & Ali, 2009), and in one case (Spangler, Schieche, Ilg, Maier, & Ackermann, 1994) using the t-value and sample sizes for the between-group comparison. Finally, four studies (Albers et al., 2008; Jaffee et al., 2015; Jansen et al., 2010; & Thompson et al., 2015) reported regression coefficients for the effect of parenting quality on cortisol reactivity. In this case, a partial correlation was calculated with the following formula (where *k* = number of predictors in the regression analysis):

$$r_k = \frac{t_k}{\sqrt{t^2 + DF_{resid}}}$$

Multiple Effect Sizes. A number of articles reported multiple effect sizes for the same sample at different ages (*k* = 4; e.g. Spangler et al. (1994) reported correlations between parenting and cortisol when children were 3, 6 and 9 months old) or across different sub-groups of participants (*k* = 4, e.g. Dougherty et al. (2013) reported separately on depressed and non-depressed parents). Other studies reported on multiple stressor tasks (*k* = 2, e.g. Sturge-Apple, Davies, Cicchetti, & Manning (2012) used both the Strange Situation Procedure (SSP; Ainsworth, Blehar, Waters, & Wall (1978)) and a Simulated Phone Argument Task (SPAT)); or multiple cortisol samples (e.g. Conradt, Hawes, Guerin, Armstrong, Marsit, Tronick & Lester (2016) reported correlations between parenting quality and cortisol measured at 20 minutes and 30 minutes post-stressor task); or multiple parenting assessments (*k* = 11, e.g. Bosquet Enlow, King, Schreier, Howard, Rosenfield, Ritz & Wright (2014) reported separately on parenting measured during play and reunion episodes of the SFP, whilst Brummelte et al. (2011) reported an effect size for the association between both parent Affect/Gratification and Sensitivity/Organisation and child cortisol reactivity).

In order to reduce bias, only one effect size per article was included in the present analysis. Therefore, in the first scenario, data were averaged across ages sampled if the age points fell into the same 'category' (as above). Otherwise, effect sizes were recorded for the measurement that was taken most concurrently to the parenting assessment (in order to increase similarity with the majority of studies in the analysis), or otherwise, which were collected at the youngest age (due to the hypothesis that cortisol reactivity reduces as children age; Jansen et al., 2010).

Where multiple effect sizes could be calculated due to studies reporting data separately for different sub-groups within their sample, data were averaged across the groups in order to calculate one effect size. This affected four of the included studies: Brummelte et al. (2011; infants born full-term, at very low gestational age, and extremely low gestational age), Dougherty et al. (2013; depressed and non-depressed parents), Erickson, MacLean, Qualls, & Lowe (2013; infants born at very low birth weight and at normal birth weight), and Sethre-Hofstad et al. (2002; male and female infants). Study *N*'s and other coded moderators reflected totals across sub-groups accordingly.

When separate effect sizes for multiple stressor tasks were reported, scores were averaged if tasks were of the same 'type' (see above) or otherwise, data for the task considered most reliably to induce a cortisol response were selected (based on Gunnar et al., 2009).

In cases where correlations were given for more than one post-stressor cortisol measurement, data were averaged for all measurements taken between 20 and 30 minutes post-stressor. This time period is most commonly understood to represent peak cortisol reactivity to an acute stressor (Adam et al., 2007).

Finally, effect sizes relating to multiple parenting measures or multiple parenting assessment episodes were averaged. Where correlations were provided for both negatively and positively valenced concepts (e.g. synchrony and asynchrony in Thompson & Trevathan, 2008), an absolute average was calculated.

2.4 Analysis

Meta-analysis of study effect sizes, tests of heterogeneity, risk of bias, and moderator analyses were conducted with the Comprehensive Meta-Analysis programme (CMA Version 3, Borenstein, Rothstein, & Cohen, 2005). CMA allows for comparison of effect size data presented in various formats, and we therefore entered data as collected (above) for each study. The direction of the effect for scales which were scored in 'reverse' (negative parenting as opposed to positive parenting constructs) was changed so that all study effects were entered as if on the same scale. Effect sizes were then converted into Fisher's *Z* scores and their standard errors and variance computed. Analyses were performed on these scores, before the results were converted back into correlations. The *Q*-statistic was calculated to assess heterogeneity in study effects, and the I^2 statistic to estimate the proportion of variance between studies attributable to 'true' between-study differences. Subsequently, moderator analyses were conducted by comparing combined effect sizes between subsets of studies, grouped by theoretically driven moderator variables. Planned random effects models were used to conduct all meta-analyses due to the expected heterogeneity in study populations and procedures in the included studies (Hunter & Schmidt, 2000).

To estimate the impact of publication bias (the non-publication of non-significant results) on the combined effect size estimate, Duval and Tweedie's (2000a, 2000b) 'trim-and-fill' approach was used. A funnel plot was created in CMA, where each study's converted effect size (Fisher's *Z* score) was plotted against measurement precision (1/standard error), with the resulting spread of studies in the plot highlighting areas where studies are expected to exist but have not been published (i.e. studies with small samples or non-significant results). An overall effect size estimate was then re-computed with the hypothetical 'missing studies' imputed. Rosenthal's fail-safe *N* (Rosenthal, 1979) was also calculated, as an indicator of the number of hypothetical unpublished studies which would be required to reduce the combined effect size of the meta-analysis to non-significance.

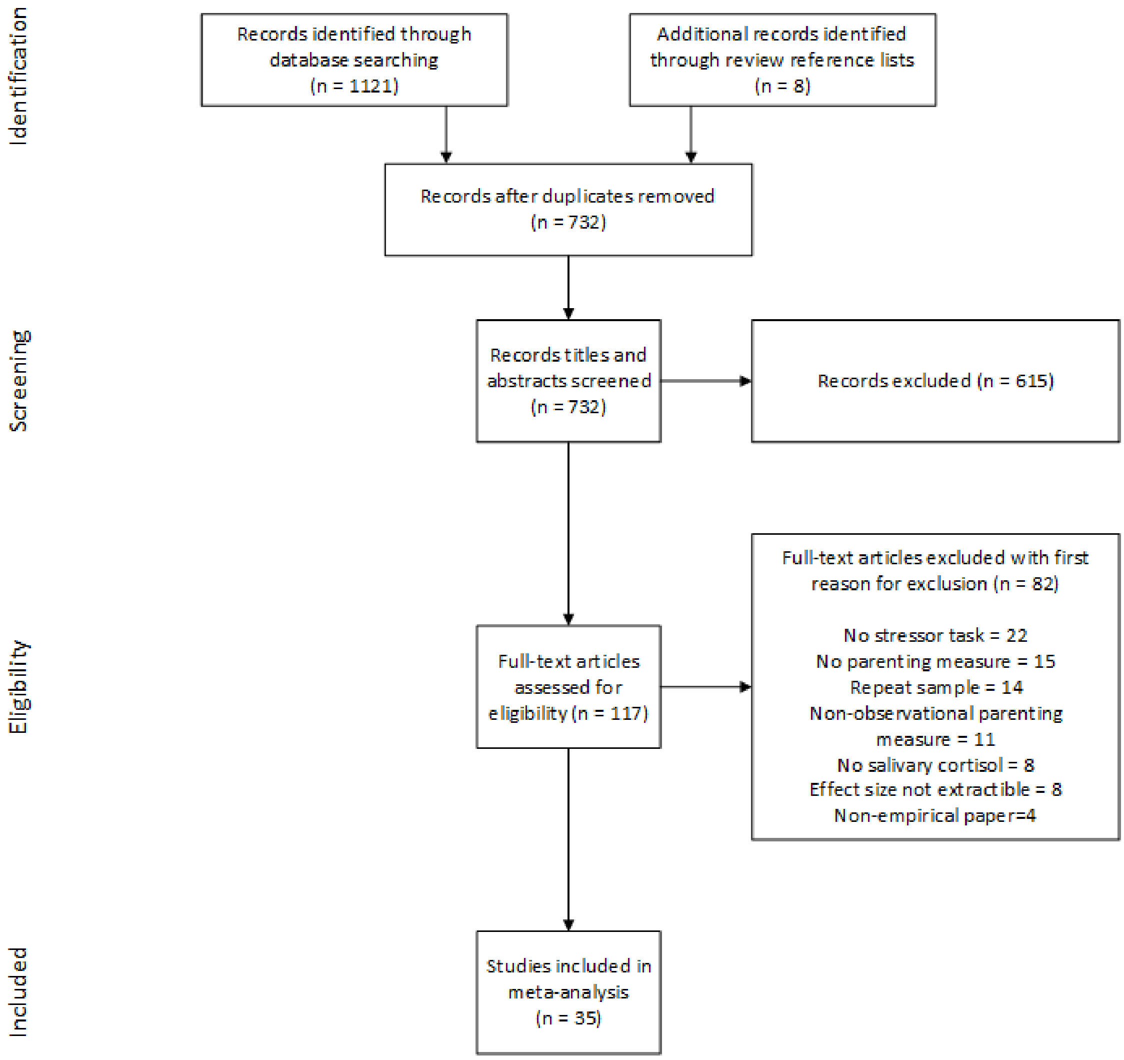
3.0 RESULTS

3.1 Search Results

In total, 1,129 articles were identified by electronic and hand searches, with 732 of these screened once duplicate records were removed. Articles were screened based on their titles and abstracts using the previously stated inclusion and exclusion criteria. One hundred and seventeen full-text articles were subsequently obtained and checked in detail against the same criteria. Full-text records were examined whenever an article had the potential to include a relevant effect (e.g. if a study included or could have included a cortisol measurement and parenting quality measure). The number of studies identified via each search method and reasons for exclusion are detailed in Figure 1.

A number (k = 18) of the eligible studies reported data from a shared sample of participants. In this scenario, the article that had measured parenting and cortisol most concurrently (as the majority of included studies were cross-sectional) and/or had the highest number of participants, was selected. Otherwise, selection was made on the basis of which article provided the most relevant data for calculation of an effect size.

Figure 1. Flow Chart of the Study Selection Process



Of the remaining 43 eligible studies, it was possible to extract an effect size from 31. The corresponding author for the other 12 studies was contacted twice to request effect size information, and two authors replied with the necessary data. In a further two cases (Erickson et al., 2013; Schieche & Spangler, 2005) where corresponding authors did not provide an effect size but the relationship between parenting quality and cortisol reactivity was reported as non-significant, studies were included in the analysis with an assumed correlation of 0.

3.2 Overview of the Included Studies

The present meta-analysis therefore included 34 articles presenting data on 35 different samples totaling 4,833 children, and ranging in size from 19 (Mörelius, et al., 2015) to 942 (Blair et al., 2015) participants. Effect sizes ranged from -0.37 (Mörelius, et al., 2015) to 0.39 (Hutt, Buss & Kiel, 2013). Most studies utilised a cross-sectional design (k = 31, 89%), whilst three (Blair et al., 2015; Davies, Sturge-Apple, Cicchetti, & Cummings, 2007; Thompson et al., 2015) were part of larger longitudinal studies (but also presented concurrently measured parenting quality and cortisol data). One paper presented data on a parenting intervention, where the control group only was included in the present meta-analysis (Mörelius et al., 2015). Tables 3 and 4 provide an outline of the final sample of papers and their key characteristics.

Sample Characteristics. Children sampled ranged between 1 month and 10 years of age, but most commonly (k = 11; 31%) study participants were aged between 3.5 and 6 months. Twenty-three (66%) studies reported on low-risk child and adult samples, and 12 presented data for samples with varied risk factors including parental mental health difficulties, low SES, family conflict and child premature birth (see Table 3 for details).

Characteristics of the Parenting Measurement. Scales and concepts capturing parenting quality greatly varied between studies. The most common domain of parenting measured was 'sensitivity' (k = 14; 40%), though 'sensitivity' coding schemes varied. About half (k = 19, 54%) of the included studies combined scales representing different aspects of parenting behaviours (e.g. sensitivity, structuring, non-hostility) by creating composite or average scores, or using data reduction methods such as principal components analysis. This resulted in at least 31 different parenting concepts reported amongst the studies. However, coded at a general level, these scales mostly represented only positive indices of parenting behaviour (k = 24, 69%). Four studies (11%) used schemes that also coded the child's behaviour.

Table 3. Characteristics of Studies included in the Systematic Review and Meta-Analysis

Author & Year	Study & Sample Characteristics				Characteristics of Parenting Quality Assessment			
	N	Age (m)	Parent Risk[a]	Child Risk	Domain[b]	Measure**	Parent-Child Measure?[c]	Independent Assessment?[d]
Albers et al., 2008	64	3m	none reported	none reported	Sensitivity, Cooperation, & Non-interference	SS	No	No
Azar et al., 2007	212	4m	Teenage mothers, 32% had a history of depression, 42% diagnosed with conduct disorder.	none reported	**Overcontrol**	CARE	No	Yes
Beijers et al., 2013	173	12m	none reported	none reported	Sensitivity	SS	No	Yes
Blair et al., 2015	942	24m	Sampled from low-income non-urban communities in high poverty areas.	none reported	Sensitive/Responsive & **Harsh/Controlling**	Adapted TTB	No	Yes
Bosquet Enlow et al., 2014	23	6m	none reported	none reported	Sensitivity	SS	No	No
Brummelte et al., 2011	73	18m	none reported	70% born at low or very-low gestational age.	Affect/Gratification & Sensitivity/Organisation	Crnic et al.	No	Yes
Conradt et al., 2016	128	4m	none reported	none reported	Responsiveness/Appropriate Touch & Acceptance/Non-Demanding	Gunning et al.	No	No
Crockett et al., 2013	62	4m	Sampled from an economically disadvantaged region.	none reported	**Disrupted behaviour**	AMBIANCE	No	No
Davies et al., 2007	178	6y	53% of parents reported martial dissatisfaction.	none reported	Warmth/Support & Positive Reinforcement	IFIRS	No	Yes
Dougherty et al., 2011	149	3.6y	38% of parents had a history of depression *	none reported	**Hostility**	TTB	No	Yes

Author & Year	Study & Sample Characteristics				Characteristics of Parenting Quality Assessment			
	N	Age (m)	Parent Risk[a]	Child Risk	Domain[b]	Measure**	Parent-Child Measure?[c]	Independent Assessment?[d]
Dougherty et al., 2013	146	4y	62% of parents have a history of depression.	none reported	**Hostility**	TTB	No	Yes
Erickson et al., 2013	53	8m	none reported	55% born at very low birth weight.	Responsiveness	**Specific**	No	No
Grant et al., 2009	88	7m	19% of mothers had a prenatal anxiety disorder*	none reported	Sensitivity	Gunning et al.	No	No
Haley & Stansbury, 2003	43	6m	none reported	none reported	Responsiveness	**Specific**	No	No
Hutt et al., 2013	66	24m	none reported	none reported	Protective behaviour	**Specific**	No	No
Jaffee et al., 2015	379	10y	Sampled parents who showed harsh, nonresponsive parenting when their child was 3 years old.	42% had experienced a recent 'traumatic event'	Physically or verbally harsh behaviours	HOME, CTS	No	Yes
Jansen et al., 2010	140	1m	none reported	none reported	Sensitivity & Cooperation	SS	No	No
Kertes et al., 2009	269	4y	none reported	none reported	Sensitivity, Structuring, Nonintrusiveness, & Nonhostility	EAS	No	Yes
Kiel & Kalomiris, 2016	99	25m	none reported	none reported	Comforting	**Specific**	No	No
Lewis & Ramsay, 1999 (1)	55	2m	none reported	none reported	Soothing	**Specific**	No	No
Lewis & Ramsay, 1999 (2)	59	2m	none reported	none reported	Soothing	**Specific**	No	Yes

Author & Year	Study & Sample Characteristics				Characteristics of Parenting Quality Assessment			
	N	Age (m)	Parent Risk[a]	Child Risk	Domain[b]	Measure**	Parent-Child Measure?[c]	Independent Assessment?[d]
Martinez-Torteya et al., 2014	153	6m	76% of mothers had a history of childhood maltreatment; & 50% had PTSD.	none reported	Behavioural Sensitivity, Engagement, Affective Sensitivity, and Positive Affect.	MIPCS	No	Yes
Mörelius et al., 2015	19	1m	none reported	100% of children born preterm	Sensitivity	SS	No	No
Muller et al., 2015	46	6m	41% of mothers diagnosed with an anxiety disorder	none reported	Matching & **Latency to Repair**	ICEP	Yes	No
O'Connnor et al., 2015	165	9.6y	Oversampling for families at 'psychsocial risk'*	none reported	Warmth/Support & **Negative/Conflict**	Hagan et al.	No	No
Ruttle et al., 2011	63	4.5y	none reported	none reported	Dyadic Behavioural Sensitivity	EAS	Yes	Yes
Schieche & Spangler, 2005	63	12m	none reported	none reported	Supportive Presence & Quality of Assistance	Matas et al.	No	Yes
Sethre-Hofstad et al., 2002	64	3y	none reported	none reported	Sensitivity	SS	No	No
Smeekens et al., 2007	101	5y	none reported	none reported	**Negative Interactions**	Erickson et al.	Yes	No
Spangler et al., 1994	34	4m	none reported	none reported	Sensitivity	SS	No	No

Author & Year	Study & Sample Characteristics				Characteristics of Parenting Quality Assessment			
	N	Age (m)	Parent Risk[a]	Child Risk	Domain[b]	Measure**	Parent-Child Measure?[c]	Independent Assessment?[d]
Sturge-Apple et al., 2012	201	24m	60% of mothers experienced interpersonal violence, & oversampling of families from impoverished backgrounds.	none reported	**Low Warmth, Hostility, Insensitivity & Disengagement**	IFIRS	No	Yes
Thomas et al., 2017	271	6m	none reported	none reported	Mother-Infant Interaction Quality	PCITS	Yes	Yes
Thompson & Trevathan, 2008	63	3m	none reported	none reported	Synchrony & **Aysnchrony**	Isabella & Belsky	Yes	Yes
Thompson et al., 2015	106	6m	none reported	none reported	Synchrony	Isabella & Belsky	Yes	Yes
van Bakel & Riksen-Walraven, 2008	83	15m	none reported	none reported	Supportive Presence, Non-intrusiveness, Adequate Structuring, Quality of Instruction & Nonhostility.	Erickson et al.	No	Yes

a *denotes that less than 40% of the sample was considered 'at risk' and therefore was not coded as 'at-risk' in the meta-analysis.

b Parenting domains are stated as in the original studies. Bold text denotes negative parenting constructs. Data reported on multiple scales were averaged for the present analyses.

c Parenting assessment coded both parent and child behaviours.

d Independence of parenting and cortisol assessments.

** **Parenting Measures:** SS = Ainsworth Sensitivity Scales (Ainsworth et al., 1978); CARE = CARE Index (Crittenden, 2004); TTB = Teaching Tasks Battery (Egeland & Heister, 1993); Crnic et al. (1983), four global 5-point rating scales; Gunning et al. (1999) Global Rating Scales of Mother-Infant Interaction; AMBIANCE = AMBIANCE Scales (Lyons-Ruth et al., 1999) of frightening, frightened, disoriented and odd behaviours; IFIRS = Iowa Family Interaction Rating Scales (Melby & Conger, 2001); Specific = Coding scheme was designed for the study; HOME = Home Observation for Measurement of the Environment (Caldwell & Bradley, 1984); CTS = Conflict Tactics Scale: Parent–Child self-report questionnaire (CTS-PC; Straus et al., 1998); EAS = Emotional Availability Scales (Biringen, Robinson & Emde, 1998); MIPCS = MACY Infant-Parent Coding System (Earls, Muzik, & Beeghly, 2009); ICEP = Infant & Caregiver Engagement Phases (ICEP-R; Reck, Noe, Cenciotti, Tronick & Weinberg, 2009); Hagan et al. (1992) Global Coding Scale; Matas, Arend & Sroufe (1978) 7-point scales for supportive presence and quality of assistance; Erickson, Sroufe & Egeland (1985) five 7-point scales for sensitivity; PCITS = Parent-Child Interaction Teaching Scale (Oxford & Finlay, 2013); Isabella & Belsky (1989) scales for Mother-Infant Synchrony.

Table 4. Further Characteristics of Studies included in the Systematic Review and Meta-Analysis

Author & Year	**Characteristics of the Cortisol Measurement**					**Effect Size**
	Task Type	**Task Details**[a]	**Task Success**[b]	**Index**[c]	**Cortisol Controls**[d]	***r***[e]
Albers et al., 2008	Physical	Bathing	Yes	Slope	Some	-0.12
Azar et al., 2007	Frustration	Arm-restraint	No	T2	Some	-0.01
Beijers et al., 2013	Relational	SSP	Yes	Reactivity	All	0.07
Blair et al., 2015	Frustration	Toy frustration & Frightening mask presentation	No	T2	Some	-0.14
Bosquet Enlow et al., 2014	Frustration	SFP	Not stated	AUCi	Some	-0.32
Brummelte et al., 2011	Other[1]	Cognitive assessment	Yes	T2	All	-0.01
Conradt et al., 2016	Frustration	Modified SFP	Not stated	T2	Some	-0.29
Crockett et al., 2013	Frustration	SFP	Yes	T2	All	-0.06
Davies et al., 2007	Other	SPAT	Yes	Slope	Some	0.2
Dougherty et al., 2011	Fear	Stranger approach & 2 Toy frustration procedures	Yes	AUCi	Some	-0.19
Dougherty et al., 2013	Frustration	Rigged failure task	Not stated	AUCi	All	-0.02
Erickson et al., 2013	Frustration	Modified SFP	No	Reactivity	Some	**0**
Grant et al., 2009	Frustration	Modified SFP	No	T2	All	-0.35
Haley & Stansbury, 2003	Frustration	Modified SFP	Yes	T2	Some	0.04

Author & Year	Characteristics of the Cortisol Measurement					Effect Size
	Task Type	Task Details[a]	Task Success[b]	Index[c]	Cortisol Controls[d]	*r*[e]
Hutt et al., 2013	Fear	Stranger approach, Stranger working, Clown approach, Puppet show, Robot approach & Spider approach	Not stated	% change	All	0.39
Jaffee et al., 2015	Frustration	Rigged failure task	Yes	Reactivity	All	0.03
Jansen et al., 2010	Physical	Bathing	Yes	Reactivity	Some	-0.06
Kertes et al., 2009	Fear	Risk room[2]	Yes	Reactivity	Some	0.04
Kiel & Kalomiris, 2016	Fear	Clown approach & Spider approach	Not stated	Slope	Some	0.11
Lewis & Ramsay, 1999 (1)	Physical	Physical exam & Inoculation	Not stated	Reactivity	Some	0.2
Lewis & Ramsay, 1999 (2)	Physical	Physical exam & Inoculation	Not stated	Reactivity	Some	0.1
Martinez-Torteya et al., 2014	Frustration	SFP	No	% change	All	-0.29
Mörelius et al., 2015	Physical	Diaper change	Not stated	Reactivity	Some	-0.37
Muller et al., 2015	Frustration	SFP	No	AUCi	Some	-0.27
O'Connnor et al., 2015	Relational	'Hot topic' discussion/problem-solving with parent	No	Slope	Some	-0.09
Ruttle et al., 2011	Other	Cognitive assessment	Not stated	Slope	Some	-0.04
Schieche & Spangler, 2005	Relational	SSP	Not stated	T2	Some	**0**

Author & Year	Characteristics of the Cortisol Measurement					Effect Size
	Task Type	Task Details[a]	Task Success[b]	Index[c]	Cortisol Controls[d]	*r*[e]
Sethre-Hofstad et al., 2002	Fear	Balance beam	Not stated	Reactivity	Some	-0.05
Smeekens et al., 2007	Relational	Emotional memories discussion with parent	No	Reactivity	Some	-0.18
Spangler et al., 1994	Relational	Free play & Routine (e.g. diaper change) with parent	No	Reactivity	Some	-0.35
Sturge-Apple et al., 2012	Relational	SSP[3]	Yes	T2	All	-0.18
Thomas et al., 2017	Frustration	Toy frustration & Arm-restraint	Yes	AUCi	All	-0.17
Thompson & Trevathan, 2008	Other	Preferential looking task	No	Reactivity	All	-0.09
Thompson et al., 2015	Other	Preferential looking task	No	Reactivity	All	0.11
van Bakel & Riksen-Walraven, 2008	Fear	Stranger approach & Robot approach	Yes	Reactivity	All	0.11

a. SSP = Strange Situation Procedure (Ainsworth et al., 1978); SFP = Still Face Paradigm (Tronick et al., 1978); SPAT = Simulated Phone Argument Task.
b. Task success = did the stressor task create a mean significant cortisol increase for the sample?
c. The index used to measure cortisol. Slope = slope of the line between baseline and post-stressor values; T2 = Value post-stressor; Reactivity = difference between pre and post-stressor values; AUCi – area under the curve with respect to increase; % change = percent change between pre and post-stressor values.
d. The study controlled for all or some of the recommendations adapted from Hansen et al. (2011) for reliable measurement of cortisol (see above).
e. Correlation between parenting quality and children's cortisol reactivity. Bolded 0 values were assumed based on reported non-significant correlations in those studies.
1. Study also presents data following a 5 minute mother-child interaction period, which is not included in the present review.
2. Risk room = a room containing novel objects (LabTAB; Goldsmith et al., 1999). Study also presents data on cortisol change between risk room and a stranger approach task, not included in the present review.
3. Study also presents data from a SPAT task, not included in the present review.

Characteristics of the Cortisol Measurement. Characteristics of the cortisol assessment also varied greatly amongst the included studies. Tasks intended to frustrate children were the most commonly used (*k* = 13, 37%), but studies also used fear induction (17%), threat to social relationships (17%), physical handling (9%), and pain (6%). Five studies used tasks which were not categorisable with any of these codes: cognitive assessment (Brummelte et al., 2011; Ruttle et al., 2011), learning tasks (Thompson et al., 2015; Thompson & Trevathan, 2008) and a simulated phone argument between the child's parents (Blair et al., 2015). No studies used tasks designed to test peer relationships or which were primarily based on social evaluation, likely due to the young age of most study samples. About two thirds (*k* = 22; 63%) of the study tasks either did not elicit a mean cortisol increase amongst the study sample or studies did not report if they had. Finally, the most common (*k* = 13, 37%) cortisol index correlated with parenting quality was the difference between pre- and post-task cortisol concentrations ('reactivity').

Study Quality. Studies were evaluated on aspects of their parenting and cortisol measurements. Most (*k* = 29, 83%) used coding schemes with well-established validity and reliability in their assessment of parenting quality. Exceptions were six studies where study-specific coding schemes had been developed. These tended to evaluate infrequently measured parenting behaviours, including *soothing* (Lewis & Ramsay, 1999 (1) & (2)), *comforting* (Kiel & Kalomiris, 2016), and *protective behaviour* (Hutt et al., 2013); but also *responsiveness* (Erickson et al., 2013; Haley & Stansbury, 2003). Roughly half (49%) of the studies assessed parenting concurrently with the stressor task intended to elicit child cortisol. In terms of the quality of study procedures for measuring cortisol, we found that there was at least one missing criteria (not stated or explicitly not met) in 51% of the included studies. Most frequently, this was control of the child's last eating time before cortisol was sampled.

3.3 Association between Parenting Quality and Cortisol Reactivity

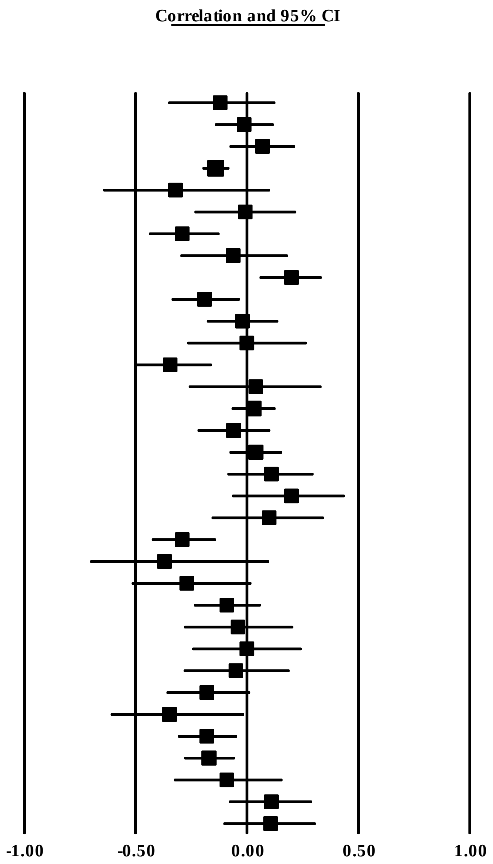
For each study a weighted effect size was calculated under a random effects model, which is presented graphically in Figure 2. Across 35 studies, a combined negative effect of r = -.06 (95% CI: -.12, -.00; Z = -2.10; p = .036) was found, suggesting that parenting quality and child cortisol were significantly, but only weakly associated with one another overall. Removal of one outlying study (Hutt et al., 2013) based on a high standardised residual error (Z = 2.7) increased the overall effect estimate to r = -.07 (95% CI: -.12, -.02; Z = -2.66, p = .008). The remainder of the analyses were subsequently conducted on 34 studies.

Heterogeneity. The overall effect estimate suggested that higher parenting quality is associated with lower child cortisol reactivity in response to stress. However, the direction and magnitude of the effect varied substantially between studies, with some noting no significant relationship between these variables, and others noting either positive or negative effects (Q = 83.64, p < .001). Over half (I^2 = 60.5%) of the variability in individual effect size estimates was attributable to differential aspects of the studies (rather than measurement error). It has been suggested that I^2 scores of this magnitude indicate moderate heterogeneity between studies (Higgins, Thompson, Deeks, & Altman, 2003).

Sensitivity Analyses. In order to evaluate the robustness of the result, sensitivity analyses were performed. These analyses assessed the degree to which the pooled effect size changed each time a single study was left out of the analysis. The overall correlation between parenting quality and child cortisol reactivity did not vary much: ranging from -.06 (when either Grant et al., 2009 or Martinez-Torteya et al., 2014 was left out) to -.08 (when Davies et al., 2007 was left out). Removing the studies for which we assumed an effect size of 0 (Erickson et al., 2013; Schieche & Spangler, 2005) resulted in a combined effect estimate of r = -.07 (95% CI: -.12, -.02), p = .007, which did not differ from the effect size estimate for all 34 studies.

Figure 2. Forest Plot of Weighted Effect Sizes, 95% Confidence Intervals, and Z- and p-values for each Study in the Meta-Analysis

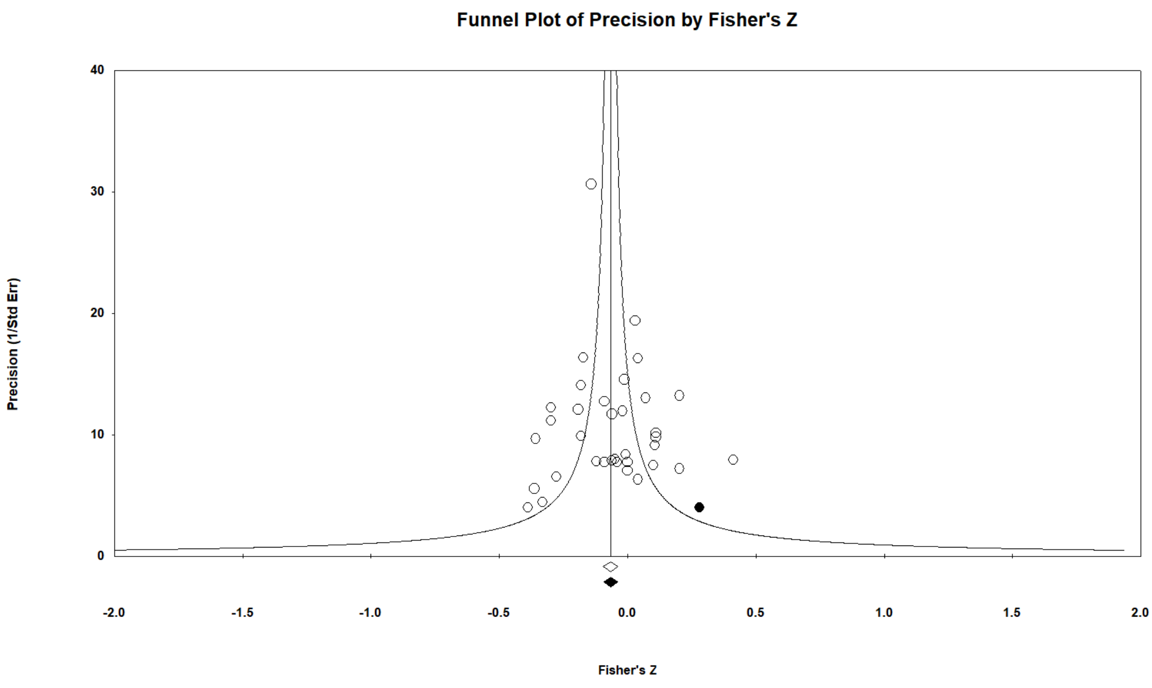
Study name	Correlation	Lower limit	Upper limit	Z-Value	p-Value
Albers et al., 2008	-0.120	-0.355	0.130	-0.942	0.346
Azar et al., 2007	-0.012	-0.146	0.122	-0.175	0.861
Beijers et al., 2013	0.070	-0.080	0.217	0.914	0.361
Blair et al., 2015	-0.140	-0.202	-0.077	-4.318	0.000
Bosquet Enlow et al., 2014	-0.320	-0.647	0.106	-1.483	0.138
Brummelte et al., 2011	-0.008	-0.238	0.222	-0.067	0.947
Conradt et al., 2016	-0.290	-0.441	-0.123	-3.338	0.001
Crockett et al., 2013	-0.061	-0.301	0.185	-0.485	0.628
Davies et al., 2007	0.200	0.055	0.337	2.682	0.007
Dougherty et al., 2011	-0.190	-0.340	-0.030	-2.324	0.020
Dougherty et al., 2013	-0.020	-0.182	0.143	-0.239	0.811
Erickson et al., 2013	0.000	-0.270	0.270	0.000	1.000
Grant et al., 2009	-0.345	-0.509	-0.155	-3.474	0.001
Haley & Stansbury, 2003	0.040	-0.264	0.336	0.253	0.800
Jaffee et al., 2015	0.030	-0.071	0.130	0.582	0.561
Jansen et al., 2010	-0.060	-0.224	0.107	-0.703	0.482
Kertes et al., 2009	0.040	-0.080	0.159	0.653	0.514
Kiel & Kalomiris, 2016	0.110	-0.089	0.301	1.082	0.279
Lewis & Ramsay, 1999 (1)	0.200	-0.069	0.442	1.462	0.144
Lewis & Ramsay, 1999 (2)	0.100	-0.160	0.347	0.751	0.453
Martinez-Torteya et al., 2014	-0.290	-0.429	-0.138	-3.657	0.000
Morelius et al., 2015	-0.370	-0.706	0.101	-1.554	0.120
Muller et al., 2015	-0.270	-0.520	0.022	-1.816	0.069
O'Connnor et al., 2015	-0.090	-0.239	0.064	-1.149	0.251
Ruttle et al., 2011	-0.040	-0.285	0.210	-0.310	0.757
Schieche & Spangler, 2005	0.000	-0.248	0.248	0.000	1.000
Sethre-Hofstad et al., 2002	-0.050	-0.286	0.193	-0.397	0.692
Smeekens et al., 2007	-0.180	-0.363	0.016	-1.802	0.072
Spangler et al., 1994	-0.348	-0.614	-0.011	-2.020	0.043
Sturge-Apple et al., 2012	-0.180	-0.311	-0.043	-2.561	0.010
Thomas et al., 2017	-0.170	-0.283	-0.052	-2.810	0.005
Thompson & Trevathan, 2008	-0.090	-0.330	0.161	-0.699	0.485
Thompson et al., 2015	0.110	-0.082	0.295	1.121	0.262
van Bakel & Riksen-Walraven, 2008	0.106	-0.107	0.311	0.976	0.329



Risk of Bias. Studies with a smaller sample size or with nil effects may have a lower chance of publication, therefore leading to overestimation of the combined effect size in meta-analysis. Rosenthal's fail-safe *N* was calculated to estimate the number of hypothetical unpublished studies reporting a correlation of 0 that would be required to reduce the observed relationship in this meta-analysis to non-significance. This number was 140, which did not exceed Rosenthal's (1991) criterion of 180 (5*k*+10, where *k* = number of included studies), and therefore suggests that the effect size observed here could be impacted by non-publication or non-inclusion of studies reporting null results. The number of studies required to nullify the present effect may furthermore be fewer than 140, given that based on the observed heterogeneity in the direction of effects observed, some unpublished studies may have found a positive relationship between parenting quality and cortisol reactivity rather than simply no effect.

The 'trim-and-fill' approach (Duval & Tweedie, 2000a, 2000b) was also employed to estimate the likely impact of publication bias on the combined effect size for this meta-analysis. Results suggested that only one study was likely to be missing: reporting on a positive relationship between parenting quality and cortisol reactivity (on the right of the funnel plot; Figure 3). The recomputed combined effect size under a random effects model, with the hypothetical missing study imputed did not differ from that observed across all 34 studies included in the analysis (*r* = -.07, 95% CI: -.11, -.02, *Q* = 85.39).

Figure 3. Precision Funnel Plot of Fisher's Z Scores (effect sizes), with one Study Imputed



Note. The white circles represent studies included in the analysis, and the black circle is the trim-and-fill imputed study. The white and black rhombuses represent observed and adjusted overall effect sizes, respectively.

3.4 Moderator Analyses

The high variability found between studies indicates the existence of moderators to the relationship between parenting quality and cortisol reactivity (Diener, Hilsenroth, & Weinberger, 2009). Hypothesised categorical moderator variables were assessed for their impact on effect size estimates using sub-group analyses. Results are provided in Table 5.

Few of the hypothesised moderators were found to have a significant effect on the relationship between the two variables of interest, although in most cases evidence of a significant relationship between parenting quality and child cortisol reactivity was only found in certain subgroups of studies. The lack of consistency in effect sizes within these sub-groups however means that we cannot be confident that these between-group differences were not due to chance.

Contrary to expectation, there was no robust, significant effect of child age, child or family 'risk' status, or characteristics of the parenting measure, although the sub-group comparison for child age approached significance. Post-hoc analysis revealed a significant difference between studies of children aged between 3.5 and 6.4 months of age (k = 11) in comparison to any other age (k = 23), Q = 5.50, p = 0.019, with the former group observed to have a larger average negative effect (r = -.16 and r = -.03 respectively).

In addition, evidence of a significant relationship between greater parenting quality and lesser cortisol reactivity was only observed in studies using frustration tasks to elicit cortisol (r = -.13), but the overall comparison between studies using different types of task also only approached significance. In this analysis, studies using 'mild physical' or 'pain' stressors were combined into one group, and those using less common tasks ('other' category) were not included due to small numbers.

Table 5. Random-effects Meta- and Moderator Analyses of the Relationship between Parenting Quality and Child Cortisol Reactivity

	k	*n*	*r*	95% CI	Contrast *Q*	Contrast *p*
Total Set	**34**	**4,767**	**-0.07****	**-0.12, -0.02**		
Age					7.82	0.050
0m - 3.4m	6	443	0.01	-0.11, 0.14		
3.5m - 6.4m	11	1,098	-0.16***	-0.24, -0.07		
6.5m – 2.4y	7	1,613	-0.09	-0.18, 0.01		
2.5y – 11y	10	1,613	-0.01	-0.09, 0.07		
Family Risk					0.02	0.893
None reported	25	2,448	-0.07*	-0.13, -0.00		
Yes	9	2,319	-0.07	-0.16, 0.02		
Child Risk					0.35	0.554
None reported	30	4,243	-0.07**	-0.13, -0.02		
Yes	4	524	-0.02	-0.18, 0.14		
Parenting Construct					0.27	0.875
Positive	23	2,258	-0.06	-0.12, 0.01		
Negative	7	1,250	-0.08	-0.19, 0.02		
Both	4	1,259	-0.09	-0.23, 0.05		
Parent-Child Measure					0.40	0.526
No	28	4,117	-0.06*	-0.12, -0.01		
Yes	6	650	-0.10	-0.22, 0.02		
Parenting Measure					5.36	**0.021**
Well-validated	29	4,458	-0.09**	-0.14, -0.04		
Study-specific	5	309	0.09	-0.05, 0.24		
Independent Parenting Assessment					2.72	0.099
Independent	18	3,583	-0.04	-0.10, 0.03		
Interdependent	16	1,184	-0.12*	-0.20, -0.04		
Stressor Task Type					7.50	0.057
Frustration	13	2,546	-0.13***	-0.21, -0.06		
Relational	6	737	-0.10	-0.21, 0.01		
Fear	6	842	0.04	-0.07, 0.15		
Physical	5	337	-0.02	-0.16, 0.13		
Stressor Task Successful?					4.40	**0.036**
Yes	13	2,085	-0.03	-0.10, 0.05		
No	11	1,963	-0.14**	-0.22, -0.06		
Cortisol Measurement Index					12.96	**0.005**
Reactivity/Peak Reactivity	14	1,598	0.00	-0.06, 0.07		
T2	9	1,812	-0.13**	-0.20, -0.06		
AUCi	5	635	-0.16**	-0.26, -0.05		
Slope	5	569	0.03	-0.08, 0.14		
Cortisol Confounders					0.195	0.659
Some controlled	19	2,647	-0.06	-0.13, 0.01		
All controlled	16	2,120	-0.08*	-0.15, -0.01		

Note. *k* = number of studies; CI = confidence intervals.
*p < .05, **p < .01, ***p < .001.

Aspects of study quality and measurement of key variables were found to be important: studies using a non-validated parenting measure reported a combined and non-significant effect in the opposite direction (*r* = .09) to that found in studies using well-established instruments (*r* = -.09). Likewise, the index used to measure cortisol reactivity was also a significant moderator of its observed relationship with parenting quality. Evidence of a significant relationship was only found in studies using AUCi (*r* = -.16) and T2 cortisol values (*r* = -.13), and their combined effect sizes were also larger than studies using other indices. Finally, and against expectation, the negative correlation between parenting quality and child cortisol reactivity was only significant (and was stronger) when studies' stressor tasks *did not* work (did not significantly raise mean cortisol levels in the sample). Studies that did not report on the 'success' of their stressor tasks were not included in this comparison.

The significant moderators were entered into a meta-regression model where cortisol measurement indices were dummy coded into three variables: AUCi, T2 value, and slope. The model contained 24 studies (due to exclusion of studies which did not report on the success of the stressor task). After controlling for the effect of the other variables in the model, only the success of the stressor task and the use of the AUCi index remained significant in explaining variance in effect size between studies. The model fit the data Q = 14.27, p = .014, explaining around half of the variance between studies (R^2 = 0.47). Variable coefficients are presented in Table 6.

Table 6. Meta-Regression for Moderators of the Relationship between Parenting Quality and Child Cortisol Reactivity

Variable	Coefficient	95% CI	SE	p
Stressor task successful	.13	.03, .23	.05	**.011**
Parent measure well-validated	-.10	-.35, .14	.12	.394
Uses AUCi cortisol	-.19	-.34, -.03	.08	**.017**
Uses T2 value cortisol	-.06	-.18, .05	.06	.266
Uses Slope cortisol	.06	-.10, .21	.08	.462

4.0 DISCUSSION

4.1 Summary Effect

Investigations of the relationship between parenting quality and children's cortisol reactivity to acute challenge have produced mixed results. Despite parenting being posited as the most important factor in the development of the HPA axis, with the potential to both cause stress and buffer against it (e.g. Gunnar & Hostinar, 2015), a number of studies have failed to find a relationship between parenting and cortisol. Others have observed both positive and negative relationships, whereby parenting quality has sometimes been associated with greater child cortisol reactivity, and in other studies, with lesser child cortisol reactivity. The present paper represents the first attempt to systematically review and analyse this literature, with a view to statistically summarising the observed relationship between these variables, and its moderators. Combined effects from 34 studies found a significant, though small, negative association between parenting quality and child cortisol reactivity. Therefore, as predicted by a large body of animal research and extant theory about the development of the HPA axis (e.g. Gunnar & Donzella, 2002), the child literature on balance suggests that children experiencing a higher quality of parental care tend to react less strongly physiologically to acute laboratory challenge than children experiencing less sensitive care. Given that greater cortisol reactivity has been linked to both concurrent and future mental and physical health difficulties and other markers of adjustment, this finding may suggest that cortisol physiology is another means by which parents regulate and support their children's wellbeing (Gunnar & Hostinar, 2015; Luecken & Lemery, 2004).

Though the majority of studies included in the present analysis were cross-sectional, precluding causal attributions of the summary results, mechanisms by which parenting might help or hinder HPA regulation have been speculated. At a young age, sensitive parents' presence may buffer children's stress responses (e.g. Gunnar et al., 1992), perhaps by providing safety cues which alter the child's perception of threat (Gunnar & Hostinar, 2015), so that the threshold for a cortisol reaction is heightened. Later, children may internalise their caregiving experiences through the learning of healthy cognitive, affective and behavioural coping skills, which support self-regulation of the cortisol response. Meanwhile, children who experience lower quality parenting may react more readily to stressors, due to ineffective parental stress buffering, or if parents are experienced as a direct source of stress (Tarullo & Gunnar, 2006). Del Giudice, Ellis, and Shirtcliff (2011) have suggested that in supportive environments, a lowered threshold for HPA activation allows children to benefit from their environment through exploration and learning. This idea mirrors theories about other aspects of child development, in which sensitive parenting helps the child feel secure to explore his or her environment whilst being able to seek regulation from the parent when distressed (Bowlby, 1969).

4.2 Moderators

Our analyses suggested that there was little impact of potential publication bias on the negative relationship we observed between greater parenting quality and lowered child cortisol reactivity. However, as expected, there was a moderate amount of heterogeneity in study effects, both in the strength and direction of the relationship observed therein. On the one hand, it is notable that the summary result remained significant despite this variability. On the other, the very small effect size suggests that the association may not be robust. Caution is therefore required in the interpretation of the combined effect size. Moderator analysis, on the other hand, can identify subsets of studies where effect sizes are more robust.

Approximately 60% of the heterogeneity in study effects in this meta-analysis was estimated to be a reflection of true between-study differences rather than measurement error. We therefore examined a number of theoretically driven potential moderators as explanations of this, and found the relationship between parenting quality and child cortisol to be significantly moderated by the measurement index used to quantify cortisol, and the success of the study task in eliciting a significant mean cortisol increase amongst the participants. Although other indicators of study quality were not reliably related to study effects, we also found that the quality of the coding scheme used to quantify parenting quality may have been important: studies which used their own scheme had large confidence intervals, and many found positive (as opposed to the predicted negative) effects. However, this factor did not remain significant in a meta-regression of these variables.

There was variation in the statistical techniques and methods used to conceptualise cortisol reactivity in the included studies. Most calculated the difference between pre- and post-task cortisol values (‘reactivity’), whilst the next most common method was to give the value for post-stressor cortisol (T2 value). As suggested in previous critique of the literature (Atkinson et al., 2016; Khoury et al., 2015), we did find that the index used made a difference to the strength of the relationship between parenting and cortisol reactivity, despite all the measures used (apart from T2 cortisol) being closely related to one another statistically (see Khoury et al., 2015). In particular, only studies using AUCi or T2 cortisol values showed a significant overall association, and had larger and more reliable, negative summary effects. AUCi represents the area under the curve with respect to increase or change, when multiple cortisol samples are plotted on a graph against time. It has been argued that this measure best represents the flexible ‘allostatic’ nature of cortisol activity, and indeed of ‘regulation’, as it captures cortisol peak and return to baseline following an acute stress experience (Atkinson et al., 2016; Fox et al., 2006). The use of multiple time sampling to measure AUCi may also avoid possible bias and noise affecting other cortisol indices such as delta cortisol, which are subject to individual variability in peak cortisol response time (e.g. Blair et al., 2008; Ramsay & Lewis, 2003) and initial cortisol values (Jin, 1992). Interestingly, studies using T2 cortisol values also reported stronger negative effects between parenting and cortisol. This index has been conceptualised as similar to a cortisol baseline value (Khoury et al., 2015), raising the possibility that baseline cortisol values are also reliably affected by parenting quality. However, the moderating effect of this index did not remain significant when entered into a regression analysis with the other significant moderators.

Another common explanation for disparities in the child cortisol literature has been the mild nature of many laboratory stressor tasks. This could confound investigations of reactivity because many children do not show physiological reactions to the intended challenge. Indeed, about a third of studies in this meta-analysis did not report mean cortisol increases pre- to post-stressor (and a further third did not report on their success). However, we found that it was studies where tasks *had not worked* that a significant and stronger negative effect was found for parenting quality. Therefore, when study children did not find a task stressful on average, and parenting was of a higher quality, children tended to have lower cortisol. One way of interpreting this unexpected result, is that the effects of parenting quality on children's cortisol is more apparent when children are *not* acutely stressed. Or, in other words, more robustly stressful situations have the ability to over-ride the buffering effects of parental sensitivity. This would suggest that parental influence on HPA function may be more important to everyday functioning (or, perhaps, basal cortisol levels) where mild to moderate stressors are regularly encountered, than it is in high stress environments. Environmental stress has previously been found to moderate the effects of parental sensitivity on other child outcomes, for example attachment security is more weakly associated with parenting in lower socio-economic status or clinical samples (De Wolff & van IJzendoorn, 1997). Similarly, although we did not find contextual risk factors (in the parent or child) to significantly moderate the results of the present meta-analysis, there was some indication that parenting quality was only associated with lowered cortisol reactivity in samples where there was no contextual risk.

Contrary to expectation, we did not find that the child's age, the types of stressor task used, or aspects of the parenting measure (other than its validity) reliably explained differences in study effects. Previous meta-analyses have found that children tend to respond less to acute stressors as they age (e.g. Gunnar et al., 2009; Jansen et al., 2010), which has been attributed to either the non-success of laboratory stressors typically used with older children, or a period of child hypo-responsivity to stress. Although our results do not allow us to compare child reactivity at different ages, it was apparent that age-variation was not a reliable explanation for differences in the relationship with parenting quality. We did find that compared to other age groups, studies of children aged between 3.5 and 6.4 months had a significantly larger combined negative effect size. However, the majority of studies in this age range used frustration-eliciting tasks (see below).

Tasks involving maternal separation or physical pain have tended to most reliably elicit cortisol in laboratory investigations, whilst those intending to elicit emotion (frustration, anger or fear) have in many cases failed to cause cortisol to increase in most children (Gunnar et al., 2009). These difficulties have been put forward as another possible explanation for disparities amongst studies assessing parenting quality and children's cortisol reactions (e.g. Atkinson et al., 2016). Again, our results did not support this hypothesis. However, it was notable that we only observed a significant relationship between greater parenting quality and lesser child cortisol in studies using frustration tasks. If these tasks were particularly unsuccessful at eliciting cortisol, this may relate to our finding that situations in which children were *less likely* to mount a cortisol response, were those in which effects of parenting quality were significant. However, our results do not allow us to determine whether such interactions between task type and task 'success' were apparent.

In addition, as the SFP (Tronick et al., 1978) was used in two thirds of the studies in the 'frustration' category, this raises the tentative possibility that tasks in which the parent-child relationship was under direct strain yielded the strongest relationship between parenting and cortisol. There is growing evidence that parenting predicts greater cortisol reactivity to tasks in which the mother violates the child's expectations (e.g. Bosquet Enlow et al., 2014).

4.3 Limitations

As in other systematic reviews of child cortisol reactivity, the results of the present review were limited by the heterogeneity of the extant literature. Concerns about the comparability of results of studies utilising different designs and methodology to measure cortisol have prevented other researchers from conducting meta-analyses in this field (e.g. Hunter et al., 2011; Jansen et al., 2010). This heterogeneity also applied to the methods and conceptions of parenting quality used, and the overall quality of the studies we included here. Our results should therefore be subject to caution in their interpretation, particularly as the combined effect size observed was small and the included moderators were unable to explain a substantial amount of the variance between individual study's effects. However, we would argue that as a systematic and meta-analytic review of the field, the present work has benefit for a controversial and 'muddy' literature such as this one. De Wolff and van IJzendoorn (1997) have previously suggested that meta-analysis 'brings to order' large, inconsistent bodies of literature. In this case, we can conclude that, although small, the relationship between parenting quality and child cortisol reactivity was found to be reasonably robust to the impact of publication bias or the effects of third variables, providing some support for long-held assertions of the importance of parenting quality for child cortisol which are apparent in the literature.

However, it should be highlighted that as the majority of studies included in the present analyses were cross-sectional, we are not able to conclude causation in the relationship between better parenting quality and lowered child cortisol reactivity. It is possible that children of sensitive parents are pre-disposed to be less physiologically reactive, although the emerging results of intervention studies provide some clue as to the likely direction of effects (e.g. Bakermans-Kranenburg et al., 2008; Bernard et al., 2015). Similarly, we cannot rule out possible effects of pre-natal influences on the child HPA axis, as there is some evidence of 'fetal programming' of cortisol by such experiences (Gunnar & Vasquez, 2006). Results are also limited in their generalisability to situations outside of the laboratory (where the majority of included studies were conducted), and finally, by other kinds of bias, such as in the selection criteria for study inclusion, and coding procedures. Literature searches, study selection, and the coding of study moderators were all conducted by a single researcher, which limits the reliability of the findings. Reliability checks by a second researcher would be required to ensure the replicability of the decisions made for study inclusion and moderator coding in this study, so as to reduce potential bias.

Doubtlessly, the HPA system is complex and subject to wide inter-individual variance. However, we did not find that many of the predicted moderator variables reliably impacted the relationship between parenting quality and child cortisol. Oftentimes, these analyses were also limited by heterogeneity, as it was necessary to combine very different types of parenting measure, adverse context, and types of stress task into broad categories in order to compare sub-groups. Despite this, some comparisons may still have been underpowered, and many of the subtleties in understanding the results of individual studies were lost. For instance, Kertes et al. (2009) found that maternal insensitivity predicted heightened cortisol responses only amongst socially inhibited children; Conradt et al. (2016) found that a negative relationship was only significant when parents were depressed; and Brummelte et al. (2011) found that cortisol in children born at very low birth weight was more related to parenting than in children born at a normal weight, but these differences were obscured in the present analysis. However, most of the included studies did not study the effects of potential third variables, perhaps as they also seem to produce varying results.

4.4 Clinical Implications

Despite these difficulties, the observed association between parenting and child cortisol reactivity in this analysis, did suggest that more sensitive parenting is associated with lowered child physiological stress in the face of mild to moderate challenge. The association was small, meaning that it is likely that there are other factors influencing child cortisol reactions which are either more strongly correlated, or which interact with parenting to produce individual differences, as in the few cases noted above. In speculating about the clinical significance of this general finding, a key issue is 'what does small mean?' when we are talking about biological measures. Or in other words, what size of effect would be considered clinically significant? Moderately strong, or even weak, correlations may nevertheless indicate powerful causal mechanisms (De Wolff & van IJzendoorn, 1997), although what these may be are only hypothesised at present.

Nonetheless, preliminary evidence on the relationship between parenting and child cortisol has already formed the basis for the design of interventions that minimise the burden of HPA dysregulation and therefore, decrease the risk for future pathology, in populations who have experienced extreme deviations in parenting (Hostinar & Gunnar, 2013). Ten-week sensitivity training for foster parents of previously maltreated infants, results in the normalisation of their basal cortisol levels (Dozier et al., 2006). Even improvements in 'normal' parenting without intervention appears to be beneficial: in another study, greater parenting sensitivity post-adoption led to normalised child cortisol reactivity to a parent separation task in teenagers (DePasquale, Raby, Hoye, & Dozier, 2018). Other researchers are starting to apply the cortisol literature to the development of preventative intervention programmes, for example in pre-empting the development of adolescent depression (Adam, Sutton, Doane, & Mineka, 2008). However, we don't yet know if such interventions could be successfully applied to non-chronically stressed populations of children, or whether results are long lasting.

Another question of interest here relates to the extent (and under which circumstances) that differences in cortisol reactivity confer resilience, rather than risk. Obradovic and collegaues (Obradovic, Bush, Stamperdahl, Adler & Boyce, 2010) found that cortisol reactivity to laboratory challenge was associated with more maladaptive outcomes in the context of high adversity but with *better* adaptation in the context of low adversity. They have suggested that stress reactivity can be conceptualised as 'biological sensitivity to context', for good or for ill (Boyce & Ellis, 2005).

The clinical implications of the relationship between parenting and child cortisol reactivity may therefore only be knowable when considering context, and a multitude of other individual difference factors. For instance, in a review of the links between early caregiving, cortisol regulation and physical health conditions, Luecken & Lemery (2004) explore evidence that pathways from parenting quality to cortisol dysregulation are through the former's interactions with children's genetic vulnerabilities, psychosocial factors (such as social isolation) and/or self-regulation abilities. A few studies are now also emphasising the importance of the dynamic relationships between stress systems: as well as being influenced by maternal behaviour, children's cortisol may also synchronise with that of their mothers (Atkinson et al., 2016; Ruttle et al., 2011). Other researchers caution that the HPA system is only one actor amongst many interconnected systems that work in tandem when an individual responds to their environment (Fox et al., 2006). For instance, interactions between cortisol and the sympathetic nervous system (SNS) may explain moderate amounts of unique variance in children's extenalising and internalising problems (El-Sheikh, Erath, Buckhalt, Granger, & Mize, 2008).

4.5 Conclusion

Meta-analysis of 34 studies confirmed that there is a negative, though weak relationship between parenting and child cortisol. The result is consistent with the idea that more sensitive parents prevent their children from mounting large physiological responses to laboratory stressors, which may represent a protective factor against the development of stress-related pathologies. However, unanswered questions remain about the clinical significance and the substantive and methodological moderators of this association. The long-term effects of parenting on child cortisol have rarely been examined, and there are likely many important moderators to consider. Our results suggest that future studies would benefit from using AUCi to measure cortisol, and from using well-validated parenting measures to improve their reliability. Future research may also examine the relationship between parenting and cortisol longitudinally, and under conditions of varying stress, to test the ‘limits’ of the influence of parenting, and the conditions under which it is more or less important for child cortisol.

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Part 2: Empirical Paper

Longitudinal, Mediational, and Reciprocal Pathways between Maternal Sensitivity, Children's Self-Regulation and Peer Relationships

ABSTRACT

Aims: Sensitive parenting and self-regulation skills are two important factors believed to be involved in the development of children's peer relationships. Conversely, relatively little is known about the effects of peer relationships on children's self-regulation abilities and the parent-child relationship. **Method**: In this study, direct and mediatory pathways from maternal sensitivity to peer popularity via child self-regulation (represented by attentional control abilities), and reciprocal linkages from peer popularity to maternal sensitivity, were investigated. Longitudinal Structural Equation Modelling was used to explore the dynamic interplay of these factors across the early school years. **Results**: A model of the data including direct and indirect bi-directional paths between maternal sensitivity, attentional control and popularity fit the data well. There was some support for the hypotheses that greater maternal sensitivity and attentional control would positively influence later child popularity, though this influence reduced over time. In turn, greater child popularity at 6-7 years (but not at 54 months) significantly predicted maternal sensitivity four years later, which was partially mediated by children's attentional control at 9-10 years. There was also evidence of reciprocal longitudinal relationships between maternal sensitivity and self-regulation throughout the elementary school years. **Conclusions**: Results increase our understanding of why some children continue to have successful relationship experiences with parents and peers throughout the early school years, and others do not; and are suggestive of the importance of the early and on-going cultivation of maternal sensitivity, and early self-regulation skills, for positive child outcomes.

1.0 INTRODUCTION

Although the importance of parent and peer relationships for child developmental outcomes is well-recognised (e.g. Collins, Maccoby, Steinberg, Hetherington, & Bornstein, 2000; Hay, 2005; Raby, Roisman, Fraley & Simpson, 2015), surprisingly little is known about how each of these types of relationship dynamically interact with child characteristics across the early school years. One such characteristic, the child's developing self-regulation skills, has received increasing attention in developmental research over the past few decades. Self-regulation, defined variously in cognitive, physiological, emotional and/or behavioural terms, is a multifaceted aspect of temperament that is biologically based but also shaped by contextual influences (Bridgett, Burt, Edwards, & Deater-Deckard, 2015).

Self-regulatory processes are thought to enable children to control prepotent responses in favour of more adaptive and/or socially acceptable strategies (Baumeister & Alquist, 2009). These skills have been linked with various markers of child psychosocial adjustment, and have been posited as a critical factor in the development of social skills and peer acceptance (Baumeister & Vohs, 2004; Bridgett et al., 2015). In this respect, there is also emerging evidence to suggest that self-regulation abilities may be a key mechanism in the positive association between high quality parenting and child peer success (e.g. Mintz, Hamre, & Hatfield, 2011). On the other hand, some theorists have supposed that self-regulation abilities may be enhanced by the opportunity to practice self-control during positive peer and parent interactions (e.g. Farley & Kim-Spoon, 2014), and that children with good self-regulation skills may elicit more sensitive parenting (e.g. van Leeuwen, Mervielde, Braet, & Bosmans, 2004). This raises the possibility that parent and peer relationships, and self-regulation abilities, are reciprocally associated with one another throughout development.

In order to increase our understanding of the processes which cause some children to maintain positive trajectories throughout development in terms of skills such as self-regulation and peer relationships, it is important to identify the mechanisms and directions of influence in the relationships between key skills. However, the associations between parent, peer and self-regulation factors have so far been little studied using long-term longitudinal data, weakening prior investigations of causal (directional) hypotheses. In addition, the potential effects *of* peer relationships on child and parent characteristics, as opposed to their role as an outcome of these other processes, have largely been neglected (Reitz, Zimmerman, Hutteman, Specht & Neyer, 2014). This raises the question of whether extant, and predominantly unidirectional, models of influence from parent to child effects are 'only half the story'.

The present study aims to contribute to our understanding of the development of childhood self-regulation and peer relationships using a large, longitudinal US dataset from the National Institute of Child Health and Human Development's (NICHD) Study of Early Child Care and Youth Development (SECCYD) (NICHD ECCRN, 2005). We extend the existing literature by assessing the relative longitudinal, mediational and reciprocal influences of these factors in tandem, across the transition to elementary school and through the child's early school years: a period of immense physical, emotional, social and cognitive development (van Lier & Deater-Deckard, 2016).

1.1 Peer Relationships and Parenting

Attaining and maintaining positive relationships with peers in childhood and adolescence is an important developmental task associated with psychosocial adjustment and school success (Rubin et al., 2004). Research suggests that positive peer relationships provide children with social support and promote social skills development (Parker, Rubin, Price, & DeRosier, 1996), with the effects of early social success seemingly carried forward into adolescence (Bagwell, Newcomb, & Bukowski, 1998). As children age, friends take on increasingly important roles in providing support, intimacy, and a context in which children are able to learn socio-cultural norms and practice social skills (Furman & Buhrmester, 1992; Rubin, Bukowski, & Parker, 2006).

Equally, the consequences of failing to develop positive relationships with peers are reflected in examples of concurrent and later child maladjustment (Parker, Rubin, Erath, Wojslawowicz, & Buskirk, 2006). Having fewer friends, or less positive relationships with peers, implies that children do not experience the beneficial effects of these relationships. In addition, accumulating evidence suggests that adverse social experiences with peers during early schooling are linked with serious negative outcomes including externalising and internalising problems, academic difficulties, and lowered self-esteem (van Lier & Deater-Deckard, 2016). In the long-term, chronic peer rejection in childhood has been found to sensitise neural responses to social exclusion during adolescence, which together with the reduced opportunities for peer support and social skills development, may explain how negative peer relationship experiences lead to adverse effects on mental health over time (Will, van Lier, Crone, & Güroğl, 2016).

Taken together, this evidence suggests that the identification of processes which either support or hinder children in forming positive relationships with their peers is an important task for developmental research. One fruitful line of study in this regard has investigated the link between early parenting practices and parent-child relations, and the later development of children's social relationships. Warm, supportive, 'sensitive' parenting (Ainsworth, Bell & Stayton, 1974; Domitrovich & Bierman, 2001) has been associated with better outcomes in terms of children's popularity amongst their peers, their social behaviour, and social problem-solving skills (e.g. Domitrovich & Bierman, 2001; MacKinnon-Lewis et al., 1994; Raby et al., 2015; Rubin & Burgess, 2002). Sensitive parenting has also been associated with lower peer rejection and victimisation amongst school children (Rubin et al., 2004), whilst hostile parenting practices seem to predict children's problem behaviours with peers (e.g. O'Connor, Jenkins, Hewitt, DeFries, & Plomin, 2003).

Parents who are 'sensitive' are conceptualised as being able to perceive, interpret, and respond promptly and appropriately to their child's signals, such that his or her needs are met (Ainsworth et al., 1974). Such parents may help their children develop greater social competence through a number of mechanisms. For example, social learning theory predicts that sensitive parents (themselves socially skilled) model and selectively reinforce their children's social behaviour, influencing how the child then interacts with their peers (Putallaz & Heflin, 1990). Other models attend to the effects of parenting on the child's expectations and perceptions of social relationships: Bowlby described how children internalise representations of early caregiver relationships, which influence later social cognitions and interactions (Bowlby, 1969; Dodge, 1993). Through internalised 'working models' of relationships, children are equipped with adaptive expectations of relationships and relevant social skills, which, when put to use in peer interactions, mediate the quality and success of the child's social relations. A further possibility is that sensitive parenting leads to success in children's peer relationships via the development of other skills which are used when making and maintaining friendships. One important skill in this regard may be the child's developing self-regulatory abilities.

1.2 Self-Regulation

Conceptualisations of self-regulation vary according to researchers' primary areas of interest (cognitive, emotional, behavioural, and/or physiological). However, most agree that the construct is multi-faceted and comprised of a number of inter-related systems and abilities (e.g. Baumeister & Vohs, 2004; McClelland, Cameron Ponitz, Messersmith, & Tominey, 2010). In general, self-regulation can be defined as the "exertion of control over the self by the self" (Muraven & Baumeister, 2000, pp. 247), involving the inhibition of prepotent thoughts, feelings and behaviours to maximise long-term rewards (Baumeister & Alquist, 2009), and to meet the "cognitive, emotional, and social demands of specific situations" (Ruff & Rothbart, 1996, pp. 7). For example, research from a neuro-cognitive perspective highlights components such as control of attention, cognitive flexibility, and inhibition of responses, or broadly, 'executive functioning' (Happaney, Zelazo, & Stuss, 2004), which can be measured by neuropsychological and experimental methods. Whilst in the emotional and behavioural domains, self-regulation may be displayed by a child waiting for his or her turn to answer a question in the classroom, persisting on a difficult task, or controlling his or her temper in a conflict situation (e.g. Drake, Belsky & Fearon, 2014; Gresham & Elliot, 1990; McClelland, Cameron, Wanless, & Murray, 2007; Russell, Lee, Spieker, & Oxford, 2016).

Indices of self-regulation have consistently been found to be powerful predictors of children's academic success and psychological adjustment into early adolescence (e.g. Eisenberg et al., 2001; McClelland et al., 2007). In addition, emerging evidence suggests that children and adolescents better able to self-regulate are also more likely to be socially competent and well-liked by their peers (McKown, Gumbiner, Russo, & Lipton, 2009). For instance, adolescents high in conscientiousness[4] seem to be more accepted by their peers and have higher quality concurrent (Jensen-Campbell & Malcolm, 2007) and future (Roberts & Bogg, 2004) peer relationships. Amongst young children, greater emotional regulation as measured by toddlers' use of adaptive strategies in response to frustration tasks, has been associated with greater observed cooperation and lesser conflict with same-sex peers (Calkins, Gill, Johnson, & Smith, 1999). Similarly, in a study of preschoolers enrolled in a Head Start programme, attentional control measured by a computerised task, and behavioural inhibition in a delay gratification task were positively related to teacher ratings of children's social competence, and to a lesser extent, peer popularity nominations. In addition, children who were unable to delay gratification in the task were more likely to be disliked by their peers than children who were able to inhibit their behaviour (Cybele Raver, Blackburn, Bancroft, & Torp, 1999). Baumeister and Vohs (2004) suggest that self-

[4] A personality trait reflecting the propensity to be self-controlled and hardworking, for which self-regulation is considered an early precursor (Eisenberg, Duckworth, Spinrad, & Valiente, 2014).

regulation abilities are critical for children to be responsive to social rules and therefore achieve acceptance in their peer group. Indeed, clinical evidence, often drawing on samples of children with Attention Deficit Hyperactivity Disorder, suggests that children who are rejected or victimized by peers frequently fail to attend to signals by interaction partners, and display poor self-control in social situations (Rosen et al., 2014). Low self-control has also been found to be an important predictor of peer and behavioural problems in non-clinical samples (e.g. Ng-Knight, Shelton, Riglin & McManus, 2016).

Although self-regulation abilities are believed to have a substantial intrinsic basis, evidence suggests that the environmental context also has a large role to play in their development (e.g. Krueger and Johnson, 2008; Rothbart & Bates, 2006). Within this, individual differences in parenting practices are widely considered key (e.g., Bodovoski & Farkas, 2008; Eisenberg et al., 2014; Finkenauer, Engels, & Baumeister, 2005; Roberts, Lejuez, Krueger, Richards, & Hill, 2014). In prior analyses of SECCYD data, Drake and colleagues (2014) found that attachment experiences in early life predicted the development of children's self-regulation two years later (assessed with measures of self-control in social situations and attentional control) and subsequent conscientious behavior in school. Other longitudinal investigations have similarly found that parenting practices influence the development of various self-regulation facets, including executive functioning and emotional and behavioural regulation (e.g. Bernier, Carlson, & Whipple, 2010; Frick, et al., 2018; Ispa, Su-Russell, Palermo, & Carlo, 2017), whilst further strong evidence comes from randomised interventions designed to increase sensitivity of caregiving. Lunkenheimer, et al. (2008) found that parents' observed use of positive behaviour support following a 'Family Check-Up' intervention predicted gains in self-regulation by age four, as well as into middle childhood (Chang, Shaw, Dishion, & Wilson, 2015).

1.3 Mediated and Reciprocal Relationships

Despite the wealth of literature investigating parenting precursors to children's social relationships, studies of the pathways that may help to explain the association are relatively few. However, given the evidence that parental sensitivity plays an important role in the development of both children's peer relationships and self-regulation, and that self-regulation is a key skill for building peer relationships and avoiding peer rejection, it is possible that self-regulation abilities are one mechanism through which parenting effects children's social relationships.

Some evidence of this idea has emerged from previous studies of SECCYD data. For example, Mintz and colleagues (2011) modelled the relationship between maternal sensitivity, 'effortful control' (measured with a Children's Behaviour Questionnaire, playground observations, and a student-teacher relationship scale), and six-year-old children's social competence and peer problems. They found that maternal sensitivity had a direct effect on peer relationships, which was partially mediated by effortful control. In a different analysis, preschool self-regulation (conceptualised as language, attentional and emotional control abilities) significantly mediated the effects of maternal sensitivity on first grade (6-7 years) social skills and peer relationship satisfaction (Russell et al., 2016). However, these studies are limited in several ways. As prior investigations have not utilised multiple repeated measures of parent and child characteristics, they have not been able to examine the relationships between maternal sensitivity, self-regulation, and peer relationships over an extended period of child development. Furthermore, existing studies have not assessed the potential impact of longitudinal reciprocal relationships between these variables across the school years.

The dynamic interplay between the social environment and individual's behaviours, thoughts and feelings, has long been recognised in Psychology, and has been extended to understandings of personality development (e.g. Hogan & Roberts, 2004). Despite this, the potential role for peer relationships in the development of self-regulation abilities has largely been neglected (Reitz et al., 2014). In reviewing the available literature on the development of adolescent self-regulation, Farley and Kim-Spoon (2014) proposed that peer and romantic relationships have a significant socialising effect. They have argued that a bi-directional, rather than uni-directional, model of the development of self-regulation has utility, as it recognises that the individual is shaped by the social environment but also shapes his or her social environment.

Evidence for reciprocal associations between social relationships and general trait development is somewhat mixed (Hill & Jackson, 2016), but there is some longitudinal evidence in support of the idea. For example, Meldrum and Hay (2012) found that peer relationship behaviour at age nine, temporally preceded self-control abilities at age ten; and Holmes and colleagues (Holmes, Kim-Spoon, & Deater-Deckard, 2016) showed that peer problems in childhood predicted executive functioning (comprising measures of impulsivity, working memory, reasoning, behaviour and attention) at adolescence. Conceptually, we might suppose that better peer skills—via their effects on self-regulation—may also impact how parents subsequently respond to their child, with increased self-regulation promoting positive parent-child interactions, which in turn contribute to even greater child self-regulation (Wills & Dishion, 2004). Therefore, a bi-directional model of associations between parent and peer relationships, and child self-regulation may offer an understanding of development that captures the dynamic interplay between the child and his or her environments.

1.4 The Current Study

Given the importance of self-regulation, as well as peer relationships, for child outcomes (e.g. Roberts et al., 2014), furthering our understanding of these domains, and the factors that influence them, is essential. Building on the evidence that links early parental sensitivity to the development of child self-regulation and social relationships, and that associates better self-regulation with social competence, the current study aims to investigate whether the relationship between early maternal sensitivity and children's later peer relationships is mediated by the child's self-regulation abilities. The current study will also provide a test of the hypothesised bi-directional relationship between the peer context, self-regulation abilities and parental sensitivity (Farley & Kim-Spoon, 2014). Examining a bidirectional model of influence across development may increase our understanding of why some children continue to have positive social interactions throughout the early school years, and others do not.

As much of the literature which associates children's self-regulation and social relationships focuses on pre-adolescent to adolescent children, relatively little is known about such effects in younger children. However, the period in which children transition to formal schooling is likely a sensitive period for the development of both social relationships and self-regulation abilities (Diamond, 2002; Rueda, Rothbart, Saccamanno, & Posner, 2005) as each of these skills are under increasingly greater demand when children enter the structured classroom environment (McClelland & Cameron, 2012). We therefore assess children just prior to school entry, when cognitive aspects of self-regulation begin to emerge (Rueda et al., 2005), through the elementary school years. To enhance reliability, we focus on a neuro-cognitive, objective facet of self-regulation: attentional control (e.g. Bindman, Pomerantz, & Roisman, 2015; Cadima, Verschueren, Leal, & Guedes, 2016; Drake et al., 2014), in tandem with measures of peer popularity.

As with other measures of social competence, popularity is associated with positive child outcomes (Cillessen & Rose, 2005), but also reflects the child's social context (how many friends they have and the quality of those friendships) rather than just their social skills. Hartup (1992) has suggested that children's individual characteristics interact with the social context, including peer relations, in two different ways that influence development: through dyadic relationships with close friends, and through acceptance or rejection within the larger peer group. Having a larger number of friends to 'manage' is therefore likely to involve the child displaying different skills than are required for the maintenance of fewer close friendships (Monahan & Booth La-Force, 2016), and places greater demand on self-regulation abilities. We therefore expect that popularity may be particularly important to the development of self-regulation. For example, some studies have shown that negative effects of peer experiences like victimisation, which themselves are often associated with dysregulation, are mediated by having fewer friends specifically (e.g. Hodges, Malone & Perry, 1997).

We are able to overcome gaps in the existing literature by utilising secondary longitudinal data from the NICHD SECCYD (NICHD ECCRN, 2005). The SECCYD was a four-phase, multi-site, prospective longitudinal study designed to investigate the relationships between childcare and child development from infancy to mid-adolescence. Study data were collected between 1991 and 2008 across ten locations in the United States of America. We take advantage of repeated measurements of maternal sensitivity, attentional control, and peer relationships, between the ages of approximately 4.5 (54 months) and 10-11 years (5^{th} grade). This allows us to use longitudinal structural equation modeling (SEM; Cole & Maxwell, 2003) to assess whether *change* in self-regulation mediates the effects of parenting on *change* in peer popularity across time, as well as the potential reciprocal relationships between these variables at two different measurement lags.

1.5 Hypotheses

Consistent with the extant evidence and models of parental influence on child development already summarised, we expect that *early* maternal sensitivity will be directly and positively related to children's *later* success in relationships with peers, and their *later* self-regulation abilities, throughout the early school years. Sensitive and responsive parenting is an important predictor of child outcomes in a number of psychological models of child development. This parenting may allow children to model skills that improve their responsiveness to peers and therefore their popularity (social learning theory, e.g. Pullatz & Heflin, 1990), and/or to internalise positive representations of relationships, which affect the child's subsequent prosocial behaviours with peers (attachment theory, e.g. Dodge, 1993). Likewise, sensitive parents, who are by definition well-regulated, are likely to model and reinforce regulated behaviour in their children, which is eventually 'internalised' by the child through the attachment relationship.

Preliminary evidence has suggested that through these mechanisms, parenting may have both a direct effect on child peer relations (and self-regulation), and also an indirect effect on peer relations *via* its influence on self-regulation. Better self-regulation is increasingly recognised as vital for peer acceptance because it allows a child to attend to peers and be appropriately responsive to social cues (Baumeister & Vohs, 2004). We therefore expect that the child's developing self-regulation abilities will partially mediate the relationship between parenting and child popularity with peers in the present study.

We also examine the reciprocal hypotheses that children's self-regulation ability, and through this, their parent's responsiveness, will be influenced by the child's popularity (Farley & Kim-Spoon, 2014). In the same way that social learning and attachment theories recognise that child self-regulation can be influenced by the relationship with parents, so too may relationships with peers provide a potent social environment for the practice, modelling and internalisation of social skills and self-regulatory behaviour. Within this, there is likely to be more opportunity to practice self-regulation (such as by paying attention to different peers and demonstrating social self-control) and to learn from peers when a child has a larger number of friends, and therefore we predict that increasing popularity across the school period will be associated with *later* improvements in child self-regulation. In turn, these improvements in self-regulation may also be associated with improvements in the quality of the parent-child relationship as they allow the child a greater ability to attend and respond appropriately to the parent's cues. Therefore, we expect that greater self-regulation will also predict *later* improvements in maternal sensitivity as children become 'easier to be sensitive to' (Wills & Dishion, 2016).

In summary, the present study tests an emerging model of bi-directional relationships between maternal sensitivity and the peer context, which is partially mediated by the child's self-regulation abilities (e.g. Farley & Kim-Spoon, 2014). This gives rise to the following specific hypotheses:

1. Maternal sensitivity will be positively and directly related to children's later popularity with peers.
2. Maternal sensitivity will be positively related to children's later attentional control.
3. Children's attentional control will be positively related to the child's later popularity with peers.
4. The relationship between maternal sensitivity and children's popularity will be partially mediated, longitudinally, by children's attentional control.
5. Children's popularity will be positively related to their later attentional control.
6. Children's attentional control will be positively related to later improvements in maternal sensitivity.
7. Attentional control will partially and longitudinally mediate a positive relationship between children's popularity and later maternal sensitivity.

2.0 METHOD

2.1 Ethics

Data used in the present study were collected during the second and third phases of the NICHD Study of Early Child Care and Youth Development (SECCYD; NICHD ECCRN, 2005). Ethical approval was granted to the SECCYD at its commencement in 1991 (United States Department of Health and Human Services, National Institutes of Health: Eunice

Kennedy Shriver National Institute of Child Health and Human Development, U01 HD019897), and study procedures were approved by the Human Subjects Institutional Review Board at each study site (NICHD ECCRN, 2005). The study data were subsequently made available under the terms of a Restricted Data Use Agreement by the United States Inter-University Consortium for Political and Social Research (ICPSR21942-v1; United States Department of Health and Human Services National Institutes of Health: NICHD, 2010a; 2010b; see https://www.icpsr.umich.edu/icpsrweb/DSDR/series/233).

2.2 Participants

The SECCYD sampled 1,364 children and their families from a catchment of 6,189 children who were born full-term across 31 different hospitals in the United States during specified 24-hour periods between January and November 1991. Participants were selected according to conditionally random sampling so that the sample included infants born to both mothers planning to work or study full-time (60%) or part-time (20%) in the child's first year, or stay at home (20%); and was reflective of the demographic diversity of the local sampling sites. Families were excluded from the sample if mothers were younger than 18 years, abused substances, or did not speak English; and if the infant belonged to a multiple birth, had a known disability, or remained in the hospital for more than seven days after birth. In addition, families who planned to move from the catchment area, lived more than an hour from the testing site, or who were considered to live in an extremely unsafe neighbourhood were also excluded. Of the final 1,364 participants, 53% of children were male, 24% were considered to be from an ethnic minority, 14% were born to single mothers, and 45% of children lived in families in 'poverty' or 'near poverty' according to their income-to-needs ratio. Maternal education levels were varied: 10% of children had mothers who had not completed high school, whilst 21% of mothers had completed high school, 54% had completed some or all of a college education, and 15%, a post-graduate education.

As the SECCYD progressed, non-random attrition led to lesser representation of the less advantaged children and families in the sample. By Phase II, at child age three, 34% of 1,226 remaining study children were living in poverty or near poverty, due to families both moving above the poverty line and families in poverty withdrawing from the study (NICHD, 2006); 9% of the remaining mothers had not completed high school; and 22% of children had a non-white ethnicity. By Phase III, 1,061 children and their families were retained in the study (see sample size details in Table 1).

2.3 Design and Measures

In order to investigate the longitudinal research questions posed by the present study, repeated measures of maternal sensitivity, children's attentional control, and children's peer relationships were selected from Phases II and III of the SECCYD. For each construct, varied measurement methods were selected to reduce error by shared method variance, following recommendations by Cole & Maxwell (2003). Informant methods subsequently included observation (of maternal behaviour), the child's objective task performance (of attentional control), and teacher and mother report (of peer relationships). These data were collected by trained research assistants at study testing sites, participant's homes, and children's schools (further details on study procedures are documented in NICHD ECCRN, 2005).

Table 1. Sample Details at each Wave of the SECCYD

Phase	Year	Children's Ages & School Grade	Number of Children (& their families)
I[a]	1991-94	Ages 0 to 3 years	1,364 children
II	1995-99	Ages 3 to 7 years: School entry to 1st Grade	1,226 children
III	2000-04	Ages 7 to 12 years: 2nd to 6th Grade	1,061 children

a. Data from Phase I were not used in present study.

*Maternal Sensitivity***.** Maternal sensitivity was assessed four times: when study children were 54 months, and 6-7 (1st Grade), 8-9 (3rd Grade), and 10-11 (5th Grade) years old. At each of these waves, mother-child interactions during 15-minute semi-structured interactions were observed and coded by trained observers blinded to other information about the family. The interaction tasks used varied somewhat at each wave according to the child's developmental stage, though the coding scheme used to assess maternal sensitivity remained constant. At 54 months, mothers and children engaged in two activities designed to be too difficult for the child to complete independently (an 'Etch-a-Sketch' maze and tower construction), and an activity encouraging joint play (hand puppets). At first grade, mothers and children completed a further two tasks requiring teamwork (drawing a picture on an 'Etch-a-Sketch' and a 3D puzzle activity), and there was also an opportunity to observe parent-child emotion regulation and shared affect with a task designed to elicit frustration and/or excitement (a competitive card game). At later grades (3rd and 5th grade), mother-child interactions were observed during a discussion task and planning activity.

The quality of maternal behaviour during the interaction tasks was rated using 7-point (1 = very low, 7 = very high) age-adjusted global rating scales of parent interactive behaviour, based on the Teaching Task Rating Scales developed by Egeland and Hiester (1993). A composite of three of these scales, 'supportive presence', 'respect for autonomy', and reversed 'hostility', have been used to represent a latent variable of maternal sensitivity in previous analyses of SECCYD data (e.g. Belsky, Fearon & Bell, 2007; Kok et al. 2013; NICHD ECCRN, 2005), and has been shown to have predictive validity for cognitive-academic, and socio-emotional child outcomes into adolescence (e.g. Vandell, Belsky, Burchinal, Vandergrift, & Steinberg, 2010; NICHD ECCRN, 2004, 2005). Higher composite scores represent greater maternal sensitivity. Inter-rater reliability for the coding of the maternal sensitivity composite at 54 months, and first, third and fifth grades respectively, ranged from moderate to high (r = .78; r = .83; r = .77; and r = .75), and the internal consistency (Cronbach's alpha) of the construct was good (α = .84; α = .82; α = .79; and α = .85 respectively).

Child's Attentional Control. To represent one facet of children's self-regulatory abilities, we selected a repeated measure of child attentional control, the Continuous Performance Test (CPT; Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991; Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956). The CPT is a standardised assessment of a child's ability to sustain attention on a 15-minute computerised task whilst continuously responding with a button press to on-screen target objects. Children completed this task at 54 months, 6-7 years (1st grade) and 9-10 years (4th grade). In the present study, we used the proportion of child responses to non-target stimuli (errors of commission), as representative of a child's ability to inhibit a prepotent response: a concept often implicated in conceptualisations of self-regulation (Bridgett et al., 2015). Higher scores therefore represent a greater number of 'inhibition' errors.

The CPT is widely used as it is considered to be unaffected by other personality attributes or intelligence (Mirsky et al., 1991). It has good reliability and content validity for children across a large age range, and test-retest reliabilities in a validation sample of 138 boys were good (ranging from r = .65 to .74; Halperin, Sharma, Greenblatt, & Schwartz, 1991). In addition, the CPT has good predictive validity for children's school achievement and cognitive functioning (Barkley, 1994), and commission errors in particular are a well-established correlate of children's behavioural problems and impulsive disorders such as Attention Deficit Hyperactivity Disorder (e.g. Belsky et al., 2007; Riccio, Reynolds & Lowe, 2001).

Child's Popularity. To assess children's peer relationships, childcare worker- or teacher-rated measures of child popularity and number of friendships were selected from data at 54 months, and 6-7 (1st grade), 9-10 (3rd grade), and 11-12 years (5th grade). At 54 months, children's professional caregiver (a day-care centre or nursery worker), and at first grade, their class teacher, completed a four-item questionnaire, designed for the SECCYD and based on work by Ladd (1983). Questions assessed how well liked children were by their peers and whether he or she had regular playmates (e.g. 'Are there children who like to play or work with the study child?'). Items were rated on 5-point scales (1 = liked by no children in the class/never true, 5 = liked by nearly all children/almost always true), giving a total score for peer popularity, where higher scores represent greater popularity in the classroom setting. At third and fifth grades, a similar but adapted measure was used, whereby teachers were asked to make 'sociometric' ratings of the study child's popularity against all other same-sex children in the class. Scores were generated by taking the total number of same-sex children in the class plus 1, minus the study child's popularity rank amongst his or her classmates, and all divided by the total number of same-sex children in the class: values closer to one therefore representing greater popularity. These ratings of child popularity had moderate internal consistency across the four data collection points, with Cronbach's alpha's ranging from α = .81 to .89.

In addition, at each wave, teachers and parents reported on the number of friends the study child had in the class or home settings, respectively. Friends were defined as children who like one another, play harmoniously, and have generally positive interactions with one another. At 54 months, professional caregivers and mothers simply reported on the number of the child's friends up to a maximum of five, whilst at later waves scale measures were used. At first grade, teachers and mothers indicated how many friends the study child had on a 5-point scale (1 = no regular playmates, 5 = several playmates and a close friend), and at third and fifth grades, a 3-point scale (1 = one friend, 2 = two to three friends, 3 = four or more friends).

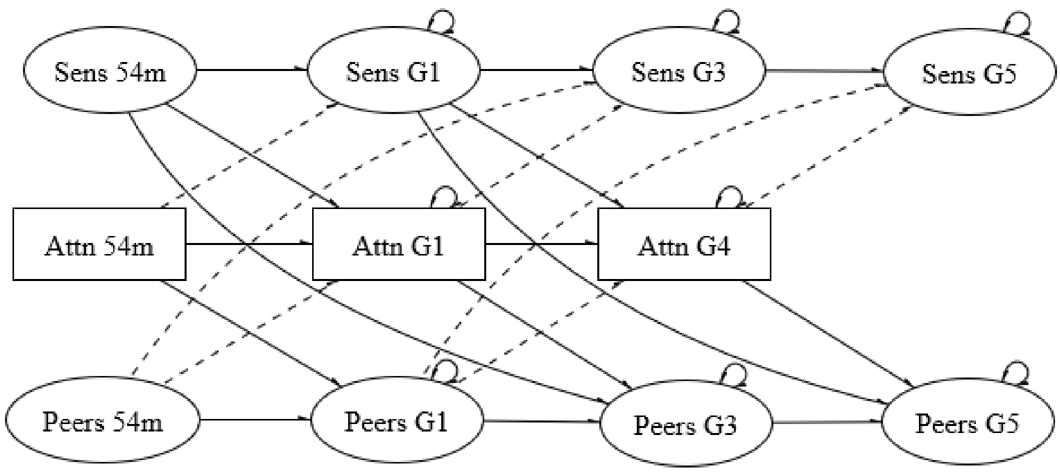
2.5 Analysis

Data were analysed using the Structural Equation Modelling (SEM) software IBM SPSS AMOS 24 (Arbuckle, 2014). Longitudinal SEMs were tested according to the present study's hypotheses on the relationships between maternal sensitivity, child self-regulation, and child popularity over time (Farrell, 1994). This method allows for the testing of directional (causal) and mediational relationships between variables, whilst enabling the researcher to control for previous measurements of the same variable, and for the impact of measurement error. This reduces the likelihood that the relationships between the study variables are over- or under-estimated (Maxwell & Cole, 2003). Within the current study, models were specified under the Full Information Maximum Likelihood approach, meaning that cases with missing data were not excluded from the analyses. This approach reduces bias through avoidance of listwise deletion of cases (Allison, 2003). In addition, constructs of interest were represented by latent variables where possible (maternal sensitivity and popularity), as this provides a more accurate and stable measurement of the effects of one variable on another by estimating the errors of measurement in the model separately from the causal model (MacCallum & Austin, 2000).

First, measurement models for each of the latent variables in the analysis were tested for their acceptability. We then tested for the stability of latent constructs over time (structural models), before estimating SEMs with direct and indirect paths between the variables of interest across measurement points. Several fit indices were inspected to assess the degree to which these models accurately reflected the data. The model X^2 represents a test of the null hypothesis that the tested model is not significantly different from the sample data. However, as X^2 is sensitive to large sample sizes, values for the Root Mean Square Error of Approximation (RMSEA) and the Comparative Fit Index (CFI) were also examined. These indices are relatively insensitive to sample size, adjust for parsimony, and in the case of RMSEA, provide confidence intervals. Although there are no universally accepted criteria for SEM fit (Crowley & Fan, 1997), RMSEA values of < .05 are generally thought to represent good fit, whilst values from .08 to .10 indicate mediocre fit. The CFI, as a measure of the complete covariation of the data, ranges from 0 to 1, with values of > .90 considered acceptable, and > .95 considered good (Bentler, 1992; Hu & Bentler, 1999).

According to prior research and theory, a number of *a priori* models were specified as per the above study hypotheses, prior to the testing of the target (final) model (Hypotheses 7-8, and illustrated in Figure 1). This method reduces the potential for confirmation bias of the targeted model by allowing nested comparisons to be made at each 'step' towards the target model (MacCallum & Austin, 2000). We therefore first tested model fit with no cross-time paths specified between latent variables; and then for the fit of the model testing the hypothesis that earlier maternal sensitivity would directly, and also indirectly via child attentional control, predict later popularity. Finally, the additional and reciprocal hypotheses that child popularity would improve later child attentional control and maternal sensitivity were tested (Figure 1). A X^2 difference test was computed at each stage in order to assess whether each nested model fit significantly better or worse than the previous model (Schermelleh-Engel, Moosbrugger, & Muller, 2003). Finally, the statistical significance of mediated paths were assessed using the Sobel test, which evaluates whether the reduction in the effect of the independent variable (maternal sensitivity or popularity respectively) after including the mediator (attentional control) is significant. A significant Sobel test suggests that there is significant mediation by the 'third' variable.

Figure 1. Final Longitudinal Structural Equation Model to be tested in the Current Study



Note. Single-headed arrows represent the influence of one variable on another. Paths within-constructs are shown between measurement points for each latent or observed construct, representing stability in those constructs across time. The paths testing the direct and mediated effects of maternal sensitivity on peer outcomes across time are shown with solid arrows, and tests of reciprocal paths with dashed arrows. Observed variables and error terms are not shown on this diagram.
Sens = Maternal Sensitivity; Attn = Attentional Control; Peers = Peer Popularity
54m = 54 months; G1 = 1st grade; G3 = 3rd grade; G4 = 4th grade; G5 = 5th grade

3.0 RESULTS

3.1 Descriptive Statistics

Prior to addressing the primary research questions posed by this study, descriptive statistics were computed for all variables in the analyses. Variables were examined for normality and the presence of outliers; and subsequently the CPT variable was square root transformed at each measurement due to high values for kurtosis and skew (as is often typical of reaction time data). Raw means, standard deviations and correlations for the study observed variables are presented in Tables 1 and 2.

In support of the measurement models of our SEMs, Table 2 shows that there were strong correlations amongst the intended indicators of maternal sensitivity (mean at 54m $r = .66$; 1st grade $r = .63$; 3rd grade $r = .57$; and 5th grade $r = .66$), with moderate correlations amongst indicators of peer relationships at each wave (mean at 54m r = .20; 1st grade r = .24; 3rd grade r = .26; and 5th grade r = .28).

3.2 Within-Construct Longitudinal Models

Cross-time stability in the latent constructs for maternal sensitivity and peer relationships was tested for first. Attentional control was measured by a single observed variable and therefore, stability in this variable across time was estimated from the raw correlations. Testing revealed that the longitudinal model for each construct satisfactorily fit the data, suggesting that a latent variable for maternal sensitivity and peer popularity respectively, explained stability in scores within each construct across measurements.

Maternal sensitivity. Maternal sensitivity was estimated from observed measures of maternal hostility (reversed), respect for autonomy, and supportive presence. In the longitudinal model for maternal sensitivity from 54 months to fifth grade, there were significant correlated errors between measures of maternal hostility (reversed), and supportive presence, at 54 months and first grade, and between all three indicators of maternal sensitivity at third and fifth grades. With these correlations included, the model was significantly different to the data (likely due to the large sample size), $X^2(46) = 241.94$, $p < .001$, but fit indices indicated there was a good fit, CFI = .97, RMSEA = .056 (90% CI for RMSEA = .049, .063). Standardised and unstandardised parameter estimates and standard errors for the paths between each measurement of maternal sensitivity are presented in Table 4.

Attentional Control. Attentional control, as measured by commission errors on the CPT, correlated moderately well between each wave: r = .26 (p < .01) between 54 months and 1st grade and r = .43 (p < .01) between 1st and 4th grade.

Popularity. The latent construct for peer popularity was stable over time, although the strength of the paths between measurements increased as the child aged (see Table 4), possibly due to the change in informant from 54 months (professional caregiver)

Table 2. Means and Standard Deviations of Study Observed Variables

Latent Variable Observed Variable	**n**	**Mean**	**Standard Deviation**
Maternal Sensitivity at 54m			
Supportive Presence	1,040	5.16	1.30
Respect for Autonomy	1,040	5.22	1.11
Hostility	1,040	1.43	.89
Maternal Sensitivity at 1st grade			
Supportive Presence	1,004	5.16	1.39
Respect for Autonomy	1,004	5.26	1.16
Hostility	1,004	1.53	.93
Maternal Sensitivity at 3rd grade			
Supportive Presence	982	4.99	1.07
Respect for Autonomy	982	4.89	1.02
Hostility	982	1.54	.83
Maternal Sensitivity at 5th grade			
Supportive Presence	929	5.11	.94
Respect for Autonomy	929	4.98	.94
Hostility	929	1.59	.87
Attentional Control at 54m	1,002	.08	.12
Attentional Control at 1st grade	996	.03	.04
Attentional Control at 4th grade	928	.02	.03
Peer Popularity at 54m			
Peer Status	717	16.78	2.84
Number of Friends - Teacher	716	3.96	1.36
Number of Friends - Mother	1,042	4.47	.89
Peer Popularity at 1st grade			
Peer Status	1,000	16.14	3.16
Number of Friends - Teacher	1,003	4.40	.86
Number of Friends - Mother	972	4.13	1.28
Peer Popularity at 3rd grade			
Popularity	939	.61	.24
Number of Friends - Teacher	974	2.54	.61
Number of Friends - Mother	1,018	2.77	.48
Peer Popularity at 5th grade			
Popularity	893	.61	.25
Number of Friends - Teacher	925	2.49	.71
Number of Friends - Mother	1,013	2.67	.62

Table 3. Correlations between Study Observed Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Supportive Presence at 54m	1														
2. Respect for Autonomy at 54m	.720**	1													
3. Hostility at 54m	-.608**	-.637**	1												
4. Supportive Presence at G1	.487**	.390**	-.351**	1											
5. Respect for Autonomy at G1	.398**	.370**	-.344**	.705**	1										
6. Hostility at G1	-.315**	-.262**	.381**	-.568**	-.603**	1									
7. Supportive Presence at G3	.389**	.339**	-.286**	.436**	.453**	-.321**	1								
8. Respect for Autonomy at G3	.310**	.291**	-.276**	.336**	.385**	-.274**	.769**	1							
9. Hostility at G3	-.201**	-.204**	.258**	-.217**	-.270**	.246**	-.479**	-.465**	1						
10. Supportive Presence at G5	.351**	.351**	-.290**	.413**	.384**	-.272**	.420**	.384**	-.272**	1					
11. Respect for Autonomy at G5	.300**	.341**	-.259**	.319**	.350**	-.242**	.427**	.392**	-.243**	.775**	1				
12. Hostility at G5	-.198**	-.205**	.267**	-.297**	-.312**	.312**	-.324**	-.314**	.322**	-.652**	-.546**	1			
13. Attentional Control at 54m	-.175**	-.228**	.206**	-.183**	-.181**	.138**	-.192**	-.201**	.168**	-.204**	-.177**	.163**	1		
14. Attentional Control at G1	-.200**	-.183**	.205**	-.167**	-.181**	.158**	-.155**	-.167**	.086*	-.185**	-.173**	.099**	.261**	1	
15. Attentional Control at G4	-.205**	-.215**	.195**	-.153**	-.182**	.110**	-.184**	-.182**	.097**	-.211**	-.188**	.100**	.224**	.433**	1
16. Peer Status at 54m	.053	.026	-.003	.067	.060	-.024	.051	.037	-.112**	.100*	.067	-.023	-.017	-.033	-.018
17. No. of Friends - Teacher at 54m	.000	-.013	-.024	.037	.045	-.054	.056	.078	-.060	.060	.016	.008	.021	.004	-.070
18. No. of Friends - Mum at 54m	.117**	.057	-.044	.097**	.055	-.011	.092**	.062	-.012	.079*	.065	-.019	-.051	-.007	-.006
19. Peer Status at G1	.144**	.119**	-.097**	.112**	.100**	-.059	.158**	.168**	-.145**	.168**	.167**	-.092**	-.166**	-.160**	-.182**

Table 3. Cont.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
20. No. of Friends – Teacher at G1	.076*	.052	-.040	.071*	.067*	-.054	.092**	.079*	-.022	.097**	.073*	-.065	-.095**	-.097**	-.033
21. No. of Friends - Mum at G1	.098**	.041	-.017	.107**	.116**	-.036	.152**	.115*	-.039	.090	.095**	-.055	-.014	-.013	-.037
22. Popularity at G3	.116**	.108**	-.109**	.126**	.106**	-.095**	.104**	.118**	-.117**	.105**	.099**	-.087*	-.150**	-.171**	-.123**
23. No. of Friends - Teacher at G3	.089**	.096**	-.075*	.116**	.100**	-.069*	.095**	.086*	-.145**	.173**	.144**	-.100**	-.121**	-.130**	-.091**
24. No. of Friends – Mum at G3	.099**	.057	.016	.067*	.050	.004	.040	.014	-.055	.103**	.056	-.048	-.093**	.016	-.057
25. Popularity at G5	.134**	.109**	-.122**	.132**	.083*	-.028	.112**	.123**	-.112**	.094**	.083*	-.059	-.103**	-.106**	-.138**
26. No. of Friends - Teacher at G5	.106**	.085*	-.096**	.071*	.060	-.002	.097**	.093**	-.101**	.113**	.117**	-.058	-.158**	-.133**	-.112**
27. No. of Friends - Mum at G5	.177**	.146**	-.096**	.184**	.160**	-.078*	.160**	.156**	-.066*	.111**	.124**	-.075*	-.095**	-.100**	-.099**

	16	17	18	19	20	21	22	23	24	25	26	27
16. Peer Status at 54m	1											
17. Number of Friends at 54m	.432**	1										
18. Has Friends? at 54m	.062	.113**	1									
19. Peer Status at G1	.270**	.075	.099**	1								
20. Number of Friends at G1	.190**	.081*	.062	.469**	1							
21. Has Friends? at G1	.043	.052	.225**	.125**	.113**	1						
22. Popularity at G3	.176**	.109**	.045	.348**	.209**	.075*	1					
23. No. of Friends - Teacher at G3	.144**	.035	.023	.230**	.165**	.094**	.484**	1				
24. No. of Friends – Mum at G3	.031	-.013	.160**	.146**	.117**	.185**	.120**	.161**	1			

Table 3. Cont.

	16	17	18	19	20	21	22	23	24	25	26	27
25. Popularity at G5	.169**	.071	.086*	.328**	.202**	.086*	.419**	.298**	.142**	1		
26. No. of Friends - Teacher at G5	.121**	.048	.077*	.214**	.173**	.077*	.232**	.242**	.097**	.514**	1	
27. No. of Friends - Mum at G5	.136**	.133**	.240**	.156**	.176**	.230**	.128**	.139**	.348**	.150**	.176**	1

Note. 54m = 54 months; G1 = 1st grade; G3 = 3rd grade; G4 = 4th grade; G5 = 5th grade
* *p* < .05 ** *p* < .01

to first to fifth grades (school teachers). There were significant correlated errors of measurement in the longitudinal model between mothers' reports of the child's number of friendships at all adjacent measurement points (54m and 1st grade, 1st grade and 3rd grade, 3rd grade and 5th grade). With these correlations added into the model, fit was acceptable, although the chi-square test was significant due to the large sample size, $X^2(48) = 177.94$, $p < .001$, CFI = .92, RMSEA = .045 (90% CI for RMSEA = .038, .052).

Table 4. Standardised and Unstandardised Path Estimates and Standard Errors for the Within-Construct Longitudinal Models

	54m to 1st Grade			1st Grade to 3rd Grade			3rd Grade to 5th Grade		
	β	*B*	*SE*	β	*B*	*SE*	β	*B*	*SE*
Maternal Sensitivity	.58	.62	.04	.59	.23	.02	.55	1.11	.09
Peer Popularity	.38	.68	.25	.58	.26	.07	.68	.92	.20

Note. All paths are significant at $p < .001$ except for the path between peer relationships at 54m to 1st grade, where $p = .006$.

3.3 Between-Construct Longitudinal Models

3.3.1 Direct and indirect effects of maternal sensitivity and attentional control

In accordance with the present study's hypotheses, a series of nested models for the direct and indirect effects of the variables in the model were tested systematically. The first set of these hypotheses concerned the effects of maternal sensitivity on child attentional control and peer popularity, and of attentional control on popularity.

Model 0. A model of the data including the simultaneous estimation of the within-construct longitudinal models for these three constructs provided a reasonable fit, $X^2(308) = 894.73$, $p < .001$, CFI = .93, RMSEA = .037 (90% CI for RMSEA = .035, .040). In this model, the initial levels at 54 months for maternal sensitivity, attentional control and popularity were allowed to correlate with one another, indicating that there were significant relationships between each construct at 54m in the expected directions. Greater maternal sensitivity at 54m was moderately associated with lesser errors in attentional control, $r = -.30$, $p < .001$, and with greater popularity, $r = .17$, $p = .004$; and lesser errors in attentional control were also associated, with greater popularity, $r = -.14$, $p = .010$.

Model 1. However, in line with Hypotheses 1 and 2, the inclusion of cross-construct paths from earlier maternal sensitivity to later attentional control, and from attentional control to later peer relationships (Model 1), resulted in a highly significant increase in model fit. Model $X^2(303) = 792.88$, $p < .001$, CFI = .94, RMSEA = .034 (90% CI for RMSEA = .032, .037); $\Delta X^2(5) = 101.85$, $p < .001$. Greater maternal sensitivity at 54 months and at first grade, significantly predicted greater child attentional control (i.e. lesser commission errors on the CPT) at first grade ($\beta = -.17$, $p < .001$) and fourth grade ($\beta = -.15$, $p < .001$) respectively, and greater attentional control at 54m, first grade, and fourth grade, significantly predicted later popularity at first ($\beta = -.25$, $p = < .001$), third ($\beta = -.10$, $p = .016$) and fifth grades ($\beta = -.09$, $p = .016$) respectively, although the effect sizes of the latter paths were small. Parameter estimates for the cross construct paths for all models are presented in Table 5.

Model 2. There was again a significant improvement in model fit when direct paths were added from maternal sensitivity to later popularity, as per Hypothesis 3, $X^2(301) = 784.73$, $p < .001$, CFI = .94, RMSEA = .034 (90% CI for RMSEA = .031, .037); $\Delta X^2(2) = 8.15$, $p < .05$. However, only the direct path between maternal sensitivity at 54m and peer popularity at third grade was significant, and not the path between sensitivity at first grade and peer popularity at fifth grade (see Table 5; Model 2).

Adding direct paths into the model for the effects of maternal sensitivity on peer popularity allowed us to test the hypothesis (no. 4) that attentional control partially mediated this relationship. A Sobel test of mediation in each path (from sensitivity at 54m to peer relationships at 3rd grade via grade 1 attentional control, and sensitivity at 1st grade to peer relationships at 5th grade via grade 3 attentional control) was, in each case, not significant, $z = 1.72$, $SE = .00$, $p = .085$, and $z = 1.90$, $SE = .00$, $p = .062$. This suggested that attentional control did not mediate the effects of maternal sensitivity on children's popularity approximately four years later.

Model 3. In the next step, Model 2 was re-tested with the effects of time-specific correlations between maternal sensitivity, attentional control, and peer popularity included (the residual errors in the prediction of these variables by their earlier measurements were allowed to correlate within the same measurement points at 1st grade, 3rd/4th grade, and 5th grade, in addition to those at 54m). Correlations between greater maternal sensitivity and lesser attentional control (greater commission errors on the CPT) were significant at each wave, r = -.29, p < .001 at 54m; r = -.09, p = .011 at first grade; and r = -.12, p = .002 at third grade, suggesting that concurrent relationships between these variables continued to be important over time. However, the relationship between attentional control and peer popularity was only significant at first grade, r = -.13, p = .011, (r = -.03, p = .437 at 54m; r = -.07, p = .171 at 3rd grade), and between maternal sensitivity and peer popularity only at 54m, r = .11, p = .043 (r = .09, p = .069 at 1st grade; r = .04, p = .398 at 3rd grade; r = .00, p = .952 at 5th grade).

In addition, although the paths predicting greater attentional control from earlier maternal sensitivity remained significant in this model, greater attentional control no longer significantly predicted *later* popularity (4 years later), except in the earliest path between attentional control at 54 months and popularity at first grade (see Table 5; Model 3). This suggested that variance in peer relationships at third and fifth grades was more strongly accounted for by *earlier* (e.g. at 1st or 3rd/4th grades respectively) *or concurrent* (e.g. at 3rd/4th or 5th grades respectively) correlations with attentional control and maternal sensitivity than by direct influences from earlier attentional control.

3.3.2 Reciprocal relationships with peer popularity

A further hypothesis (no. 5) of the present study concerned whether change in peer relationships would affect change in children's self-regulation, as measured by improvements in attentional control. It was hypothesised that greater attentional control, and better peer relationships (popularity and number of friends), may in turn also improve later maternal sensitivity, such that a reciprocal relationship may be observed between parenting, attentional control and peer relationships.

Model 4. To test these hypotheses, paths were added to the model from peer popularity to later attentional control, from attentional control to later maternal sensitivity, and directly from popularity at 54 months and first grade, to maternal sensitivity at third grade and fifth grade, respectively (the model included the concurrent correlated residual errors within waves as in Model 3). As hypothesised, the addition of reciprocal paths resulted in a highly significant improvement in model fit, therefore representing the best-fitting model tested, Model $X^2(287) = 693.47$, $p < .001$, CFI = .95, RMSEA = .032 (90% CI for RMSEA = .029, .035); $\Delta X^2(7) = 61.58$, $p < .001$. Non-significant parameters were not removed from the model as this did not affect model fit. Parameter estimates for the final model are presented in Table 5, under 'Model 4' and the standardised estimates are also diagrammed in Figure 2.

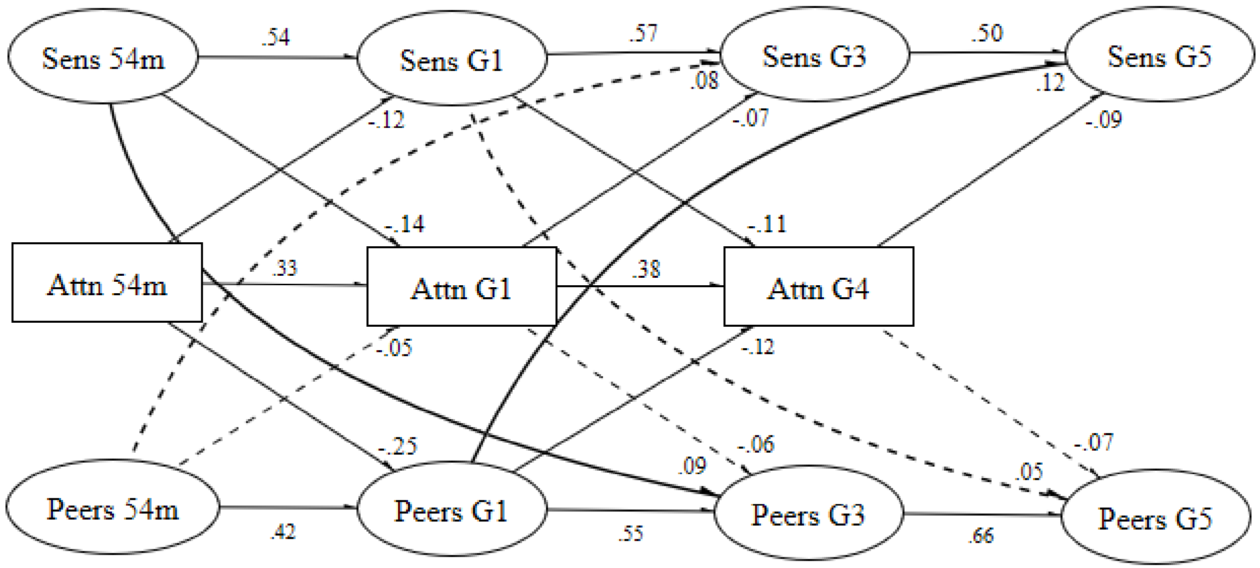
'Reverse' paths for the prediction of later attentional control and maternal sensitivity by peer popularity at 54m were non-significant, but each path predicting these variables from peer relationships at first grade were significant (see Figure 2). At first grade, greater popularity predicted later improved child attentional control ($\beta = -.12$, $p = .007$), and this in turn positively affected mothers' sensitive responding to her child four years later at fifth grade ($\beta = -.09$, $p = .005$). In addition, at each wave, attentional control significantly predicted increases in maternal sensitivity, although effect sizes for these paths were small (see Table 5, Model 4). The effects of attentional control as a mediator of the direct paths from peer relationships to maternal sensitivity was furthermore significant in the latter path from first grade to fifth grade, $z = 1.98$, $SE = .023$, $p = .048$.

Table 5. Standardised (β) and Unstandardised (B) Path Estimates and Standard Errors (SE) for the Between-Construct Longitudinal Models

	54m - 1st Grade			1st Grade – 3rd/4th Grade			4th Grade - 5th Grade			54m – 3rd Grade			1st Grade – 5th Grade		
	β	*B*	*SE*	β	*B*	*SE*	β	*B*	*SE*	β	*B*	*SE*	β	*B*	*SE*
Model 1															
Sens → Attn	-.167***	-.016	.003	-.146***	-.010	.002									
Attn → Peers	-.247***	-.316	.083	-.099*	-.093	.039	-.094*	-.168	.070						
Model 2															
Sens → Attn	-.167***	-.016	.003	-.145***	-.009	.002									
Attn → Peers	-.243***	-.306	.081	-.075	-.071	.039	-.080*	-.148	.072						
Sens → Peers										.103*	.009	.004	.044	.005	.005
Model 3															
Sens → Attn	-.154***	-.015	.003	-.133***	-.009	.002									
Attn → Peers	-.234***	-.297	.080	-.057	-.054	.039	-.064	-.118	.074						
Sens → Peers										.101*	.009	.004	.045	.005	.005
Model 4															
Sens → Attn	-.142***	-.014	.003	-.114***	-.008	.002									
Attn → Peers	-.248***	-.319	.083	-.057	-.055	.039	-.065	-.120	.075						
Sens → Peers										.091*	.008	.004	.046	.006	.005
Peers → Attn	-.046	-.031	.029	-.122*	-.042	.015									
Attn → Sens	-.124***	-.827	.208	-.072*	-.310	.134	-.093*	-1.096	.393						
Peers → Sens										.081	.232	.128	.123*	.492	.183

Note. Columns represent time lags between measurement points; rows represent paths between the named variables at each of the lags given in the columns.
Sens = Maternal Sensitivity; Attn = Attentional Control; Peers = Peer Popularity. * $p < .05$; ** $p < .005$, *** $p < .001$

Figure 2. Model 4. Structural Equation Model with Direct and Indirect Paths between Maternal Sensitivity, Attentional Control and Peer Relationships with Standardised Parameter Estimates



Note. Solid lines represent significant paths; dashed lines represent non-significant paths. Concurrent correlations between variables at each wave, observed variables and error terms are not shown on this diagram.
Sens = Maternal Sensitivity; Attn = Attentional Control; Peers = Peer Popularity
54m = 54 months; G1 = 1st grade; G3 = 3rd grade; G4 = 4th grade; G5 = 5th grade

4.0 DISCUSSION

The present study used a large, longitudinal data set from the NICHD Study of Early Child Care and Youth Development (SECCYD; NICHD ECCRN, 2005) in order to test predictive, mediational and reciprocal relationships between maternal sensitivity, children's cognitive self-regulation skills (measured with an attentional control task), and children's popularity with peers. Using longitudinal structural equation modelling (SEM) in order to control for earlier levels of each of these variables, we were able to assess how these relationships changed over a period of approximately six years, providing an integrated analysis of mother, child and peer effects across the transition from pre-school (54 months) through the early school years (10-11 years).

Overall, results showed that the best-fitting longitudinal model of the data included significant direct and indirect paths for parent (maternal sensitivity) and child variables (attentional control and peer popularity), providing some evidence of reciprocal relationships between parent and peer social factors and child traits across time. However, the longitudinal pathways between variables were most consistent for the effects of maternal sensitivity on attentional control abilities, and vice versa; whilst the relationship of peer popularity to the other factors in the analysis was more variable across the same period. This suggested that whilst maternal effects on attentional control, and the effects of child attentional control on mothers' sensitivity, remained influential throughout the pre-school to elementary school period, other factors not tested for might better explain changes in peer popularity, particularly as children approached adolescence at 10-11 years.

4.1 Parenting and Self-Regulation

First, and as expected, significant predictive paths from maternal sensitivity to child attentional control measured two years later, were found throughout the pre-school to elementary years sampled in this study. In addition, significant concurrent correlations between these variables were found at each measurement occasion (54 months, 1st grade, and 3rd-4th grade), whereby greater maternal sensitivity was predictive of later improvements in child attentional control, and was also related concurrently with better child attentional control. Notably, these significant relationships were maintained despite earlier levels of sensitivity and attentional control being controlled for in the analysis, indicating that *change* in the former predicted *change* in the latter. Together, these findings add to the large body of existing evidence that emphasises the importance of parenting practices in children's developing self-regulation skills (e.g. Eisenberg, Smith & Spinrad, 2011; Conway et al., 2014; Ispa et al., 2017), providing strong evidence for the significance of both early and current parenting through the pre-school to elementary school years. In particular, the results echo those in prior research by Drake et al. (2014) and Belsky et al. (2007), among others, who have found there to be small to moderate positive longitudinal paths between earlier maternal sensitivity and later child attentional control specifically.

The present results furthermore add to the small body of research testing bidirectional relationships between parenting and self-regulation, which has hitherto mostly been limited to studies of adolescents (see Farley & Kim-Spoon, 2014 for review). Our results on these effects in the elementary school years replicate evidence from the aforementioned study by Belsky et al. (2007) in support of a reciprocal role for attentional control: at each of three measurement lags in the present study, we found that better child attentional control predicted greater maternal sensitivity measured two years later. Our results are therefore supportive of a bidirectional, 'transactional' approach to the development of self-regulation (Sameroff, 2009): in the same way that a sensitive caregiver must appropriately attend, detect and respond to their child's cues in order to support the development of the parent-child relationship and help regulate the child's arousal (Mills-Koonce et al., 2007), so must the child direct his or her attention and responses to improve interactions with the caregiver. Well-regulated children are thought to enhance their mothers' sensitivity through their positive responses to her bids for interaction (Kochanska, Murray & Harlan, 2000; van den Boom, 1994), consequently providing these children with greater opportunity to learn or develop self-regulation skills through the higher-quality parent-child relationship.

4.2 Influences *on* Peer Relationships

Based on theory and prior research, we had also expected to find positive concurrent and longitudinal relationships between both maternal sensitivity and child attentional control with children's popularity with their peers; and posited that attentional control may be a mechanism through which the hypothesised effects of parenting on peer relationships was partially mediated (e.g. Mintz et al., 2011; Russell et al., 2016). However, we only found partial support for these hypotheses in the present study.

Maternal sensitivity measured before the school transition (at 54 months) did significantly, though weakly, predict children's popularity with peers four years later at third grade (8-9 years). However, sensitivity measured at first grade (6-7 years) did not significantly predict peer relationships another four years later at fifth grade (10-11 years). Likewise, concurrent correlations between maternal sensitivity and children's peer relationships were only significant at the earliest measurement point (54 months). These results may suggest that whilst early maternal sensitivity directly influences children's popularity with peers, later sensitivity does not. Similarly, after including concurrent correlations between attentional control and peer relationships during elementary school into our SEMs (at 1st grade and 3rd-4th grade), longitudinal paths from attentional control to child popularity were also only significant at the earliest measurement period (better attentional control measured at 54m significantly predicted greater popularity at 1st grade). Although this particular effect was the largest in the final model, indicating a moderately strong influence of attentional control on child popularity in the first year of school, the effects of attentional control diminished to non-significance as children approached adolescence. We found no evidence for mediation of parenting effects on child popularity by self-regulation in this study. The variance in children's popularity from first grade to fifth grade therefore appeared to be driven partly by early attentional control (at 54m and 1st grade) and by early parenting (at 54m), but other factors not accounted for in the present analysis may be generally more influential.

Parenting factors are well-established predictors of children's social skills and relationship quality with peers throughout childhood (e.g. Parker et al., 2006) and although, less established, emerging evidence has also suggested that facets of self-regulation similarly play important roles in increasing children's social competence and likeability (e.g. McKown et al., 2009; Ng-Knight et al., 2016). Our finding on the lack of influence of each of these factors on children's popularity during elementary school was therefore somewhat surprising, though may be explained by methodological differences between the current study and prior work.

First, much of the existing literature on the association between self-regulation and children's peer relationships has been cross-sectional and/or assessed children prior to age six (e.g. Mintz et al., 2011; Russell et al., 2016). This highlights the importance of assessing effects across an extended period of development, given that we also found effects for attentional control on child popularity at six years, but not subsequently. It may be that self-regulation is particularly influential in relation to children's popularity at this age because the period from four to seven years is considered key in the development of cognitive self-regulation skills (Rueda et al., 2005), and this also coincides with school entry. In addition, we might expect that there are different trajectories of development for differing aspects of self-regulation (Roberts, Chernyshenko, Stark, Goldberg, 2005), whereby some skills (such as emotional regulation; Vohs & Ciarocco, 2004) are more relevant to interactions with peers, and others, less so; or that the mix of pertinent skills that are most important change with age. This may explain why some studies report on positive associations between self-regulation and peer relationships in older children (e.g.

see Bennet Murphy, Laurie-Rose, Brinkman, & McNamara, 2007; Farley & Kim-Spoon, 2014).

Similarly, it would be interesting to examine whether the hypothesised influence of maternal sensitivity and attentional control on the child's social context would be supported in a replication of the present analysis with alternative peer measures. Whilst developmental research has identified several types of peer interactions that are associated with parenting practices, including social skills, relationships with a best friend, and general friendship quality, relatively less is known about the influences of parenting, and particularly self-regulation, on peer 'status' and popularity (Cillessen & Rose, 2005). We hypothesised that popularity, which may provide the child with a greater number of friends with whom skills can be practiced, may be a particularly potent peer context for the development of self-regulation skills. However, recent studies have recognised that popularity can be a 'mixed blessing' because it is also associated with risk-taking and antisocial behaviours. Therefore, it has been posited that popularity may be associated with both positive and negative parenting behaviours (Cillesen & Rose, 2005). As the present study included the former construct alone, effects of 'parenting' on popularity may have been underestimated.

In addition, the evidence supports a 'popularity-socialisation hypothesis' of peer group popularity (Allen, Porter, McFarland, Marsh & McElhaney, 2005). Whilst parenting and attentional control may initially impact peer relationships through immediate effects on non-academic skill acquisition and influence over peer selection (Shanahan, Hill, Roberts, Eccles & Friedman, 2014), their effects on the child's popularity may become more distal as popular children become increasingly influenced by their peer group. Popular children, particularly as they approach adolescence, have been found to maintain their status through increasing behaviours that receive approval in the peer group (Allen et al., 2005). Some of these behaviours, such as impulsivity (Schwartz & Hopmeyer Gorman, 2011), are characteristic of *low* self-regulation, and others may represent skills not learned through parents, but acquired from peers directly, such as communication skills and knowledge of peer group norms (O'Connor et al., 2003). Therefore, popularity may be less likely to be related to parenting and self-regulation skills, than alternative social measures, which assess the child's social competence, likeability or friendship quality; particularly in later childhood.

4.3 Influences *of* Peer Relationships

A final aim of the present study was to investigate a bidirectional model of influence, whereby peer popularity might positively influence the development of later attentional control abilities, and through these, also affect later maternal sensitivity (e.g. Farley & Kim-Spoon, 2014). Our results provide some support for this notion. Popularity measured at first grade (but not at 54 months) significantly predicted greater attentional control measured two years later and maternal sensitivity measured four years later, with the latter path partially mediated by attentional control. Research suggests that peer social interactions and play may allow children to gain competence in the regulation of their emotions and behaviours, and the cognitive flexibility required to inhibit responses and achieve success in social relationships (Pellegrini, Dupuis, & Smith, 2007). Well-regulated children may also elicit more positive parenting (as noted above).

There is little available evidence that speaks to the direct link we observed between early peer popularity and later maternal sensitivity, which may be explained by other mediating factors not included in the present analysis. For example, in a longitudinal adoption study, peer *problems* (such as victimisation and aggression) were found to predict parental negative control two years later, although parental warmth/support was unaffected (O'Connor et al., 2003), and child externalising problems have also been found to predict later parenting practices (Belsky et al., 2007). As children who score lower on self-regulation measures are more likely to have behaviour problems (Kochanska & Knaack, 2003), it may be that the less popular children in our study, also had a greater number of problem behaviours. Further analysis of this relationship may benefit from the control of behaviour and peer problems, to rule out this potential confounder.

In addition, we were only able to observe significant reciprocal relationships between popularity, attentional control, and maternal sensitivity at the latter measurement lag in the present study, and we therefore do not know if the observed reciprocal effects are reliable, or would remain into adolescence. It may be that peers exert more of an influence on attentional control and parenting once popularity and the social context is more established during the school years. However previous research has suggested that peer effects on self-regulation may actually diminish in adolescence (Holmes et al., 2016). The lack of relationship between 54-month popularity with self-regulation and maternal sensitivity, may therefore also be a result of the present study’s design. Between the earliest and later peer measures, there was a change in study respondent (from pre-school caregiver to school teacher) and peer ‘context’ (from nursery to school), which might mean that the earliest peer measurement lacked reliability, or represented a different peer construct to the other measures.

Nonetheless, the tentative evidence in this study for the reciprocal and mediated relationships between peer popularity and child and parent characteristics are suggestive that these hypotheses may be a fruitful area for future research.

4.4 Clinical Implications

The present results increase our understanding of why some children continue to have successful relationship experiences with parents and peers throughout the early school years, and others do not; and are suggestive of the importance of the early and on-going cultivation of maternal sensitivity, and early self-regulation skills, for positive child outcomes. They also indicate that other factors are clearly involved in peer popularity in this developmental period.

Through the modelling of bidirectional effects between study variables, we are able to conclude that the main direction of influence was from mother to child rather than vice versa, but that sensitive parenting and child attentional control were positively perpetuating of one another throughout elementary school. Increasing either of these traits is therefore likely to benefit the other, particularly in early childhood where the observed effects were strongest. The present results are therefore broadly supportive of interventions designed to increase sensitivity in parents of young children, as these may have beneficial impacts on the child's developing cognitive self-regulation abilities in addition to the targeted sensitive caregiving.

Our results are also supportive of early intervention as the positive effect of maternal sensitivity on child attentional control, and vice versa, diminished somewhat over the two measurement lags in this study (see Figure 2). This is consistent with research by Eisenberg and colleagues (2011) and Rueda and colleagues (2005) that has suggested there is rapid development in the skills involved in self-regulation in early childhood until age seven. Therefore it may be expected that parenting is particularly related to individual differences in self-regulation during this 'sensitive' period, and less so in later childhood. Research with young children indicates that poor self-regulation is responsive to early intervention in school settings (Blair & Diamond, 2008; Pears, Kim, Healey, Yoerger, & Fisher, 2014). However, given the on-going positive relationship between sensitivity and attentional control throughout elementary school observed in the present study, later improvements in sensitivity or self-regulation, may also be expected to have beneficial effects for child outcomes. Elementary school interventions designed to support children in developing skills in attentional control may therefore also be indicated, as an adjunct to earlier intervention.

The impact of peer relationships on self-regulation and parenting in this period is less clear, and requires further study. Factors affecting popularity appear to be largely at the level of the individual child (O'Conner et al., 2003), and given the benefits and risks that are associated with being popular, this area of research deserves greater attention (Cillesen & Rose, 2005).

4.5 Strengths and Limitations

The present study makes a unique contribution to the literature in that it combines hypothesised bidirectional and mediational effects of parent, child and peer factors into one model over an extended developmental period in which theory suggests there to be substantial growth and development in the included factors (self-regulation and peers). In many cases previous research has been limited by the use of laboratory and cross-sectional designs which weaken the case for causality and mediation (van Lier & Deater-Deckard, 2016). In the present study, the use of time-lagged dependent variables allowed us to control for past levels of the independent, mediational and dependent variables, and models were specified *a priori* and tested systematically, reducing the chance of type I errors (Lei & Wu, 2007).

However, there are also a number of limitations to the present study's design, which are attributable to the use of secondary data. Due to the original SECCYD being designed to answer a different research question, we were not able to use well-established standards of measurement for the variables of interest to the present study, compromising its reliability and validity. We therefore relied on measures of our constructs that were already available at repeated measurements in the SECCYD dataset. Although the maternal sensitivity composite used has been validated in previous research (e.g. NICHD ECCRN, 2005; Belsky et al, 2007), the peer popularity composite was not previously validated, and included single-item questionnaire variables. Similarly, it was not possible to represent child self-regulation as a latent construct, possibly introducing error into the model. Using a single measure to represent self-regulation compromised testing a more comprehensive model of this trait, as is usual in prior research, though did allow us specificity in reporting on the influence of attentional control in particular. A replication of the present study using different aspects of self-regulation would be necessary to draw more broad-based conclusions.

Further research may also be required to corroborate the observed relationships between maternal sensitivity and self-regulation with peer popularity. The measures and informants used to assess popularity at each measurement occasion varied, and, whilst the measurement models were acceptable, there were relatively weak correlations between teacher and maternal reports of the child's number of friends, raising the possibility that the popularity composite comprised multiple latent factors, particularly between 54m and the later peer measures. Though, despite this, there was good stability over time in popularity, particularly once children entered school. Peer sociometric ratings are usually considered the 'gold standard' in this field of research (Allen et al., 2005), but were unfortunately not available in the SECCYD dataset. Whilst teachers are generally good objective reporters of children's typical behaviour with peers, it is possible that some of the ways in which children interacted with, or were perceived by, their peers were not captured, possibly explaining some of the null results in the present study.

The non-significant effects observed, particularly for the direct paths between parenting and popularity, may also be attributable to long measurement lags between these variables (4 years). The effects of the more temporally distant predictors and outcomes perhaps carried through more proximal cross-lagged paths, which we did not include in the present study due to the mediational design, and thereby possibly underestimating their influence in our SEMs.

It should also be stated, that despite the fact that the SEM approach provides stronger evidence of causation than approaches which rely on cross-sectional associations, it is still ultimately a correlational method, and therefore cannot prove causation. SEMs are also susceptible to confounding from third variables which may covary with the included variables. Finally, the generalisability of the present results is somewhat limited by the SECCYD sample, which was not US nationally representative as it mainly sampled low-risk families. This also has implications for the results because maternal sensitivity seems to play more of a protective role for children at socioeconomic disadvantage, and so its effects may dissipate in the SECCYD sample (Oxford & Lee, 2011).

4.6 Conclusions

To our knowledge, the present study is one of the few to examine bidirectional relationships between self-regulation and peer experiences during the early years when self-regulation skills are emerging; and is the first to test for a reciprocal mediated effect of peers on maternal sensitivity via self-regulation. The results are broadly consistent with an ecological perspective on human development (Bronfenbrenner, 1979), where families are seen as important influences on children, but their effect can be better understood in light of the simultaneous influence of other social contexts, such as peer groups, and the individual characteristics of the child. Further research utilising models of multiple and bi-directional influence in child development may help us further our understanding of the complex and dynamic interplay of factors which are important in the early years.

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Part 3: Critical Appraisal

Introduction

This critical appraisal discusses three of the issues that arose whilst planning and undertaking the research projects presented in the current thesis. Consistent with a broad developmental psychopathology approach, the thesis describes two separate investigations of 'normal' processes which may affect child outcomes. This approach provided both opportunities and challenges. As a theoretically-driven thesis containing analyses of secondary data, there were particular practical and conceptual concerns to overcome in the work, which I reflect upon here first. I also discuss the clinical utility of the thesis in relation to my role as a Trainee Clinical Psychologist, considering the wider opportunities for research in a developmental psychopathology framework for everyday clinical practice.

Secondary Data Analysis

The present thesis presents findings from a secondary analysis of data previously collected for the National Institute of Child Health and Human Development's (NICHD) Study of Early Child Care and Youth Development (SECCYD; NICHD ECCRN, 2005). The SECCYD was a multi-site, prospective longitudinal study designed to answer questions about the relationships between early child care experiences and children's developmental outcomes. Data were collected on a large number of socio-emotional, physical and academic outcomes in over 1,000 children and their families, across approximately fifteen years from birth. As such, the NICHD dataset represents a rich source of information on factors associated with different aspects of child development. Indeed, the study has stimulated some 673 publications to date by both the original research team and 'associate researchers' who have conducted secondary analyses (see https://www.icpsr.umich.edu/icpsrweb/ICPSR/search/publications?SERIESQ=00233 for a catalogue of publications arising from the SECCYD dataset).

The depth and breadth of the SECCYD data was a major draw for the present thesis. It provided a unique opportunity to investigate key developmental research questions about the relationships between child and environmental factors across an extended period of development. These questions would not have been answerable through the relatively small-scale collection of primary cross-sectional data, that is characteristic of much psychological research. In addition, the large sample size meant that the data had high external validity and enough power to conduct complex statistical modelling of latent variables over time (longitudinal structural equation modelling, SEM), increasing both the robustness and the representativeness of the findings.

The ability to conduct longitudinal analyses using SEM was particularly rewarding, revealing some interesting and complex relationships between parents, children, and peers. The technique offers good statistical control of measurement error, increasing the reliability of its parameter estimates; and due to the simultaneous estimation of repeated measurements of the same variables, it was possible to assess how variables *changed* in relation to one another. This made it possible to draw fairly strong conclusions about the directions of effects between the study variables (i.e. which variable likely 'caused' the other and the testing of mediation effects)[5]. It was also possible to investigate a model of reciprocal influence between both the parents and the child, and between peers and the child. A belief in the interplay of the individual and his or her environment (i.e. nature and nurture), is common to most modern psychological thinking, but in practice these hypotheses are usually difficult to test with cross-sectional designs. What was notable in the research, was that the effects that parents, children and peers had on one another changed throughout the six-year period analysed: a pattern that would have been obscured had I sampled children at one point in time only.

[5] Though it should be noted that longitudinal SEM is still a correlational technique and is therefore not able to prove that one variable caused another. Experimental designs (such as randomised control trials) remain the strongest evidence of causality available in psychological research due to the control of extraneous variables.

On a personal level, there were additional advantages to conducting a secondary data study. Not least of these were the much-reduced time and insecurity associated with the avoidance of ethics submissions, participant recruitment and data collection procedures. Although these are useful skills for any aspiring researcher working in the NHS, I was instead able to spend the time 'saved' in data collection on engaging with the research literature informing my research questions, and learning new statistical techniques and computer programmes for the analysis of large-scale datasets and repeated designs (SEM and meta-analysis).

There is a pragmatic quality to secondary research in a context where practising as a clinical 'scientist-practitioner' (who both consumes and produces research outputs) is practically very difficult due to the current funding and time constraints affecting those working in NHS Trusts. There are existing opportunities for this kind of research across the NHS - which may take the form of small-scale audit and service evaluations relevant to local service provision, or larger scale research projects. Most NHS services already collect vast quantities of routine data, which ranges from local clinical records to large national datasets recording client demographics and treatment outcomes. Many of these datasets are a rich but underutilised resource of clinically very relevant and ecologically valid data, which are often limited to use for the annual reporting of national epidemiological trends in disease prevalence. For example, the National Drug Treatment Monitoring System (https://www.ndtms.net/) is maintained by Public Health England for the recording of the national prevalence of addictions and proportion of clients completing treatment in drug and alcohol services. However, the system requires services to collect data on multiple other psychosocial characteristics of clients, including main drugs of use, education, employment, sexual health, and types of intervention accessed. There are therefore opportunities to explore other research questions, such as the factors influencing national treatment effectiveness. Other examples include longitudinal datasets which monitor treatment outcomes over repeated measurements, such as the IAPT national outcome monitoring system (see Clark et al., 2017) and the UK specialist Rehabilitation Outcomes Collaborative (UK ROC) for specialist inpatient neuro-rehabilitation services (see http://www.ukroc.org/).

However, there are also unique challenges to overcome when using secondary data rather than collecting data specifically for a current project. For my part, an unexpected challenge in using the NICHD dataset was understanding the various codes and systems used to catalogue the vast amounts of data in the study, and the particular nuances of the project which caused many of the bespoke measurement tools to change throughout the life of the study. Ultimately, I spent quite some time getting to grips with extensive study manuals and searching through data files for useable variables. Difficulties in understanding the data coding schemes also led to some incidences of 'false starts' where I would begin the processes of data cleaning and preliminary analysis, only to discover that I had selected the wrong variable; or that a variable that 'looked good' from the study manuals was, in practice, unusable due to the amount of missing data or peculiarities in the scoring.

Related to this, was the need to compromise on my intended research questions and study design in order to match what was actually available in the NICHD data. For example, ideally we might have collected more data on child popularity and attentional control in order to increase the number of cross-lagged paths in the analysis, and allowing us to observe whether the effects of peers on maternal sensitivity via attentional control continued into adolescence. Therefore, the process of research design for the thesis became necessarily iterative, involving both a top-down (research question driven) and bottom-up (data driven) approach (Cheng & Phillps, 2014). Given the large number of publications already arising from the SECCYD, in practice, part of this process was also making sure that the present thesis made a novel contribution to the literature rather than repeating prior work.

Measuring Constructs

A recurring challenge in the present thesis involved making decisions about how to define and operationalise key variables. Such decisions influence the results of any piece of research. However, an additional obstacle in using the SECCYD dataset was that as the study was not designed to answer the research questions posed by the empirical paper, standard measures of key constructs were not always available.

One example of this discussed in the empirical paper, was that the reliability and validity of the 'peer popularity' construct was likely limited by the use of single item questionnaires completed by multiple respondents (professional caregivers, teachers, and parents). Early analyses did indicate that the measurement and structural models for the 'popularity' construct comprised of these measures had good enough stability to proceed with the full latent variable analyses described in the study. However, confidence in the construct would have been increased by the use of a consistent and well-validated measurement of popularity throughout. For example, 'sociometric' measures of child status which rely on peer nominations of popular, rejected, neglected or 'controversial' children are considered the gold standard in peer research (Allen et al., 2005). The use of such a measure could also have provided more nuanced results, given emerging evidence that suggests that each of these popularity 'categories' has quite different developmental trajectories (Cillesen & Rose, 2005).

Difficulties in defining 'self-regulation' were both practical and conceptual. Approaching the thesis, I had initially been interested in investigating the developmental antecedents and outcomes of conscientiousness, on which parents and peers were two possible influences (Roberts, Lejuez, Krueger, Richards, & Hill, 2014). Conscientiousness is one of the 'Big Five' personality traits identified by McCrae and John (1992), which has received special attention in recent years for its strong associations with various markers of adolescent and adult adjustment (Conti & Heckman, 2014). Having previously conducted research on the Big Five, I was personally quite struck by the apparent power of this trait for enhancing wellbeing. We had found that amongst over 47,000 individuals who had survived very distressing early experiences of sexual abuse, having high conscientiousness was one of the most important predictors of high life satisfaction amongst a raft of other abuse-specific, demographic, and personality variables (Whitelock, Lamb, & Rentfrow, 2013). The trait therefore held appeal as a possible resilience factor with the potential to limit 'common' negative outcomes associated with adverse early experiences like child sexual abuse. However, it was surprising that few studies seemed to have attempted to investigate how conscientiousness may be cultivated in early development.

The SECCYD did not include a measure of conscientiousness, and so, I drew instead on the concept of 'self-regulation' because there is evidence to suggest that this is an early precursor of the trait (e.g. Eisenberg, Duckworth, Spinrad & Valiente, 2014; Rothbart & Bates, 1998; Rothbart & Posner, 1985). 'Self-regulation' therefore seemed a good candidate for addressing my general research aims with the NICHD data, though it quickly became apparent that a reason for the seeming absence of literature 'tracking' the development of child self-regulation into adult conscientiousness, may be the lack of consensus about what self-regulation (and indeed, conscientiousness) actually 'is'.

Apparently similar concepts capturing elements of the ability to be 'self-controlled' and inhibit immediate responses to maximise longer-term rewards (Muraven & Baumeister, 2000; Ruff & Rothbart, 1996), have been described in terms of 'executive function', 'effortful control', 'self-control', 'affect regulation', 'conscientiousness', and so on. This made it difficult to decide whether these constructs describe a common set of processes simply measured at different levels of analysis (cf. Roberts, Chernyshenko, Stark, & Goldberg, 2005), or that are qualitatively and developmentally separate (cf. Dishion, 2016). Therefore, conceptually, there was a challenge in selecting which combination of ‘self-regulation’ tasks or facets might represent the most appropriate test of the present study’s hypotheses, in the absence of specific guidance in the literature.

The decision to select one cognitive facet of self-regulation, attentional control, was ultimately, largely based on methodology. Although, as discussed in the empirical paper, the evidence is also supportive of a special role for attention in cultivating successful social interaction experiences (e.g. Shin, 2012). As attentional control was measured by a computerised task completed by the child, reliability in the study was increased, and difficulties with common method variance were avoided. In addition, the combination of multiple different types of task scores into self-regulation composites, common in much of the literature, risks obscuring important developmental differences in individual facets of the construct, and/or creating measurement problems, as these measures are often weakly correlated with one another (Blair, 2003). However, a disadvantage was that it was not possible to represent attentional control as a latent variable due to a lack of comparable measures in the SECCYD dataset, and this may have increased error in our SEM estimates. This approach also sacrificed a holistic, broad understanding of self-regulation, which might reflect more than a ‘sum of its parts’. It is likely that conclusions drawn about ‘self-regulation’ in the present thesis, are neither necessarily generalisable or readily comparable, to ‘self-regulation’ research that has been carried out under different traditions with different measures.

Future studies of the reciprocal influences on the development of self-regulation may benefit from further clarification of the specific facets comprising the construct, and how these are related to one another (Dishion, 2016). A better understanding of the developmental course of self-regulation would allow for the design of interventions across the life-span to improve these important abilities. For example, according to Conti and Heckman (2014), within a developmental framework, self-regulation, executive functioning, and conscientiousness may be usefully modelled as one trait that evolves over time, within which specific aspects emerge with each stage of the life cycle. In the elementary school years, our results suggest that attentional control is one such aspect worth investing in.

Clinical Implications

The work in each chapter of this thesis has been broadly informed by a developmental psychopathology framework, which seeks to identify the biological, social and psychological mechanisms that cause human development to diverge between adaptive and maladaptive trajectories (Cicchetti, 2006). The development of mental health problems in this framework is understood in terms of interacting risk and resilience factors across multiple domains at the levels of the individual and the environment. Therefore, research on both 'typical' and 'atypical' development is considered mutually informative because each may provide clues as to the factors which might increase or decrease cumulative risk of pathology.

Therefore, although not applied clinical research, the findings of the present thesis do reflect a number of important principles of the developmental psychopathology framework that have significant implications for clinical psychologists. Substantive findings of the systematic review and empirical paper supported the relevance of early caregiving for the regulation of children's cortisol reactivity and attentional control, though clearly in each case, other factors included (and not included) in the analyses were also relevant. Not only were parent contributions important to outcomes, but so were those of the child, and of their peers, depending on the child's age. The results therefore suggested that interventions for parental sensitivity, child self-regulation, and/or social skills and making friends could each confer differing benefits at different points in early development.

Personally, this concept holds appeal because it insinuates that developmental trajectories are amenable to change at multiple points throughout development. It is therefore likely that there are opportunities for intervention and prevention throughout the lifespan, and at different levels of ‘causality’ (physiology, parent, child, peer). As a Trainee Clinical Psychologist, these ideas not only provide hope for recovery in working with people who have experienced early adversity, but also multiple possibilities when formulating and working with individuals with complex problems.

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