Child Maltreatment, Behavior Problems, And Neurocognition: Main And Mediation Effects

Naixue Cui
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Abstract
Child maltreatment, especially physical abuse, is highly prevalent in Mainland China and has been associated with childhood behavior problems. Nevertheless, pooled relationships between three types of child maltreatment (physical abuse, emotional abuse, and neglect) and childhood behavior problems in Chinese studies have not been examined using a meta-analytic approach. The neurocognitive underpinnings of these relationships remain poorly understood. Also, the possible link that neurocognitive dysfunction and BP may predispose children to high risk of physical abuse is under-investigated.

The purpose of this dissertation was to examine the interrelations among child maltreatment, childhood behavior problems, and neurocognition. Chapter 2 is a meta-analysis that examined the pooled effect sizes of relationships between the three types of child maltreatment and behavior problems in Mainland China. Built on findings from the meta-analysis, Chapter 3 tested the mediating effect of neurocognition, measured by P300 event-related potential in the relationship between physical abuse and externalizing behaviors. As a different line of inquiry, Chapter 4 tested the risk effects of neurocognition measured by IQ and behavior problems on the likelihood of physical abuse. Chapters 3 and 4 applied secondary analysis of existing data collected from the China Jintan Child Cohort Study.

The meta-analysis in Chapter 2 found that physical abuse, emotional abuse, and neglect related to a spectrum of behavior problems with approximately equal small-to-moderate effect sizes. Findings in Chapter 3 further indicated that P300 amplitude to novel stimuli mediated the relationship between maternal physical abuse and self-report externalizing behaviors. The sub-study in Chapter 4 found that child externalizing behaviors reported by mother and teacher increased the risks of physical abuse, whereas child-report externalizing behavior or mother-report internalizing behaviors related to decreased risks of physical abuse. This body of work provides a deeper understanding of the complex interrelations among child maltreatment, behavior problems, and neurocognition. Findings can inform tailored interventions to prevent child maltreatment and promote child behavioral and neurocognitive development. They also signify the urgency to build an effective child-protection system in Mainland China.

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CHILD MALTREATMENT, BEHAVIOR PROBLEMS, AND NEUROCOGNITION:
MAIN AND MEDIATION EFFECTS

Naixue Cui

A DISSERTATION
in
Nursing
Presented to the Faculties of the University of Pennsylvania
in
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CHILD MALTREATMENT, BEHAVIOR PROBLEMS, AND NEUROCOGNITION:
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Naixue Cui
DEDICATION

This dissertation is dedicated to my dearest parents, sister, and brother with my gratitude for their endless affection, love, encouragement, and support throughout my life. And it is dedicated to all the people who believed in me.
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ABSTRACT

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Child maltreatment, especially physical abuse, is highly prevalent in Mainland China and has been associated with childhood behavior problems. Nevertheless, pooled relationships between three types of child maltreatment (physical abuse, emotional abuse, and neglect) and childhood behavior problems in Chinese studies have not been examined using a meta-analytic approach. The neurocognitive underpinnings of these relationships remain poorly understood. Also, the possible link that neurocognitive dysfunction and BP may predispose children to high risk of physical abuse is under-investigated.

The purpose of this dissertation was to examine the interrelations among child maltreatment, childhood behavior problems, and neurocognition. Chapter 2 is a meta-analysis that examined the pooled effect sizes of relationships between the three types of child maltreatment and behavior problems in Mainland China. Built on findings from the meta-analysis, Chapter 3 tested the mediating effect of neurocognition, measured by P300 event-related potential in the relationship between physical abuse and externalizing behaviors. As a different line of inquiry, Chapter 4 tested the risk effects of neurocognition measured by IQ and behavior problems on the likelihood of physical abuse. Chapters 3 and 4 applied secondary analysis of existing data collected from the China Jintan Child Cohort Study.
The meta-analysis in Chapter 2 found that physical abuse, emotional abuse, and neglect related to a spectrum of behavior problems with approximately equal small-to-moderate effect sizes. Findings in Chapter 3 further indicated that P300 amplitude to novel stimuli mediated the relationship between maternal physical abuse and self-report externalizing behaviors. The sub-study in Chapter 4 found that child externalizing behaviors reported by mother and teacher increased the risks of physical abuse, whereas child-report externalizing behavior or mother-report internalizing behaviors related to decreased risks of physical abuse. This body of work provides a deeper understanding of the complex interrelations among child maltreatment, behavior problems, and neurocognition. Findings can inform tailored interventions to prevent child maltreatment and promote child behavioral and neurocognitive development. They also signify the urgency to build an effective child-protection system in Mainland China.
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CHAPTER 1: INTRODUCTION

Introduction to the Problem

Child maltreatment (CM) is prevalent worldwide and China is not excluded. Researchers estimated that the prevalence rates of three types of CM, namely physical abuse (PA), emotional abuse (EA) and neglect in the Chinese context are 36.6%, 38.6% and 41.2%, respectively (Fang et al., 2015; Ji & Finkelhor, 2015). Prior research has linked CM to a series of adverse childhood and adulthood behavioral outcomes, such as aggression, violent behaviors, depression, anxiety, and suicide (for reviews, see Dunne, Chen, & Choo, 2008; Fang et al., 2015; Ip et al., 2016). Among the outcomes, childhood behavior problems (BP) are of special concern because they are major risk factors for adulthood crime, violence, and mental disorders (for meta-analyses, see Leschied, Chiodo, Nowicki, & Rodger, 2008; Reef, Diamantopoulou, van Meurs, Verhulst, & van der Ende, 2011). However, the associations of CM and childhood BP have not been systematically examined in Chinese literature. The accumulative evidence in the field highlights the need to conduct a meta-analysis to estimate the pooled relationships between CM and childhood BP to provide strong evidence to guide practice.

The mechanisms underpinning the relationships between CM and behavioral outcomes have gained increasing attention. Evidence suggests that altered neurocognitive function may be a potential pathway linking CM to childhood BP (Shonkoff, Boyce, & McEwen, 2009; Shonkoff et al., 2012). Yet, this neurocognitive mechanism remains poorly understood.

The majority of the current literature considers child PA as a risk factor for developing BP and neurocognitive dysfunction. In contrast, emerging evidence shows
that BP or neurocognitive dysfunction may be a predisposing factor for CM (Sheehan & Watson, 2008; Xing & Wang, 2013; Xing, Wang, Zhang, He, & Zhang, 2011). However, few studies have explored the relationship between previous child IQ and later CM using a prospectively designed study in Mainland China. Additionally, different informants, such as children, parents, and teachers may have discrepancies in their perceptions of the children’s BP (Achenbach, McConaughy, & Howell, 1987). Therefore, it is necessary to explore whose perception of child behavior is attributed to CM.

These gaps in the literature highlight the need for further research to better understand the interrelations among CM, childhood BP, and neurocognition in the Chinese context. Knowledge gained from this line of research can provide empirical evidence to inform public health agencies the urgency and significance of protecting children from maltreatment. This is important given the fact that although Chinese awareness of CM as a social issue has increased since the enactment of the first Chinese special law against domestic violence in 2016, the public health implications of CM is yet to be acknowledged in Mainland China.
Background

Why Mainland China

CM is highly prevalent in the Chinese societies, especially Mainland China. A meta-analysis (Ji & Finkelhor, 2015) estimated that 36.6% of Chinese experienced some forms of PA in their childhood, which is higher than the global estimate (17.7%, Stoltenborgh et al., 2013). Even within the Chinese societies, PA is more prevalent in Mainland China (40.6%) than other Chinese societies (19.5%, Ji & Finkelhor, 2015). Similarly, EA and neglect are also very common in China (Fang et al., 2015).

The high prevalence of CM may be attributed to traditional Chinese belief of parenting. The parent–child relationship in China, especially among Han Chinese, is largely driven by a set of moral-ethical principles, named “San Gang Wu Chang (三纲五常, The Three Bonds and the Five Ethical Principles)” derived from Confucianism (Chan & Young, 2012). This ideological guideline stipulates that, in the familial hierarchy, children are expected to be submissive to and obey their parents unconditionally. Parents are responsible for training their children in morality, obedience, and in accepting responsibility for their own behaviors. When necessary, parents are

---

1 Mainland China refers to the geopolitical area of People’s Republic of China (hereafter, China) that excludes the special administrative regions of Hong Kong and Macau. Some demographic information of PRC is listed to help understand the Chinese context. China has the largest population (1.37 billion) in the world (The World Bank, 2015a). 232.9 million (17%) of the Chinese population is under age 14 (The World Bank, 2015b). There are 56 ethnic groups in China with Han Chinese accounting for 91.5% of the population and the other 55 minority ethnic groups accounting for 8.5%. Rural population accounts for 55.6% of the population (The World Bank, 2016).

2 San Gang literally refers to that “[t]he king is an exemplar for his subject; the father is a model for his son; the husband is a prime example for his wife” (Chan & Young, 2012). San Gang is implanted by following Wu Chang (Chan & Young, 2012): benevolence (仁 Ren), righteousness (义 Yi), propriety (礼 Li), wisdom (智 Zhi), and trust (信 Xin).
authorized to use harsh discipline, such as spanking and beating to correct children’s misbehavior or disobedience. A cross-culture study found that Chinese parents practiced more physical coercion when compared to authoritative American counterparts who tend to use more warmth and acceptance and value children’s autonomy (Wu et al., 2002).

The lack of an effective child protection system may also contribute to the high prevalence of CM in Mainland China. The present child welfare system in Mainland China provides services mainly to orphans and abandoned children, with little attention to maltreated children who live with parents or guardians. Very few prevention programs or services regarding CM are available for the public and at-risk families (Man et al., 2017). Chinese laws (e.g., The Constitution; Law on the Protection of Minors; Criminal Law, Article 260; Domestic Violence Act) prohibit violence and maltreatment against children; yet, law enforcement is only involved when CM results in life-threatening consequences, such as severe injuries or death (Man et al., 2017; Peng et al., 2015; Qiao & Chan, 2005). Therefore, CM in Mainland China needs to be further examined.

**Definition of Child Maltreatment**

There is no universally accepted definition of child maltreatment across nations because of cultural variations in determining what exactly is considered harmful treatment towards children in parenting practice. However, D’Antonio et al. (1992) argued that there must be common child-rearing practices and beliefs across cultures due to the shared nature of the human adult–infant relationship. The definition of CM provided by the World Health Organization (WHO), which refers to “physical and/or emotional ill-treatment, sexual abuse, or neglect or negligent treatment ... [that] results in actual or potential harm to the child’s health, survival, development or dignity” (as

CM that happens within the family is of particular concern. Family is the basic and primary unit to raise and socialize children in China. Parenting behaviors are important nurturing factors that shape children’s physical, cognitive, behavioral and social development. Harsh or negligent parenting may pose adverse effects on children. Hence, built upon the WHO’s definition of CM, this dissertation operationalizes CM perpetrators as parents, guardians, or other family members in the household, rather than other caregivers, teachers, strangers, or other adults who can manipulate children. Notably, this dissertation particularly focused on three types of CM that are commonly practiced in Chinese families, including PA, EA and neglect. Sexual abuse, although not a focus of this dissertation, is a severe type of CM that relates to negative health outcomes (e.g., for reviews, see Dunne et al., 2008; Fang et al., 2015) and should not be neglected. Table 1.1 describes the operational definitions of CM, PA, EA, and neglect in this dissertation study.
Table 1.1.

The operational definitions of child maltreatment and its three types

<table>
<thead>
<tr>
<th>Terms</th>
<th>Operational definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child maltreatment (CM)</td>
<td>All forms of physical and/or nonphysical abuse, neglect or negligent treatment by parent, guardian or other family member in the household resulting in actual or potential harm to the child’s health, survival, development or dignity. The dissertation focuses on its three forms: physical abuse, emotional abuse and neglect.</td>
</tr>
<tr>
<td>Physical abuse (PA)</td>
<td>The physical force against a child by parent, guardian or other family members in the household that results in or has a high likelihood of resulting in harm to the child’s health, survival, development or dignity. This includes hitting, beating, kicking, shaking, biting, strangling, scalding, burning, poisoning, suffocating, and other violent acts.</td>
</tr>
<tr>
<td>Emotional (EA)</td>
<td>Non-physical forms of rejection or hostile treatment by parent, guardian or other family member that may have a high probability of damaging the child’s physical or mental health, or the child’s physical, mental, spiritual, moral or social development, such as the restriction of movement, belittling, blaming, threatening, frightening, discriminating against, humiliating or ridiculing.</td>
</tr>
<tr>
<td>Neglect</td>
<td>Failure to provide for the development and well-being of the child in health, education, emotional development, nutrition, shelter or safe living conditions by parent, guardian or other family member in the household.</td>
</tr>
</tbody>
</table>

*Note.* The operational definitions were modified based on the definitions in (WHO, 2006, p. 9-10).

**Child Behavior Problems**

BP manifested specifically during childhood constitutes major risk factors for adult crime, violence, and mental disorders, such as disruptive disorders, substance abuse, anxiety, and depression (for meta-analyses, see Leschied et al., 2008; Reef et al., 2011). As such, a better understanding of childhood BP as it relates to CM can help prevent
adulthood BP by preventing BP from developing in childhood. Childhood BP have been conceptualized into two categories — externalizing and internalizing behaviors (Achenbach, 1978; Achenbach & Edelbrock, 1979). Externalizing behaviors refer to acts that exhibit low impulse control and are directed towards the social environment, which includes aggression, hyperactivity/attention deficit, and delinquency/antisocial behavior (Liu, 2004). Internalizing behaviors are conceptualized as emotional and psychological problems that are directed inward, which includes depression, anxiety, somatic complaints and suicide (Liu, Chen, & Lewis, 2011). This conceptualization shows cross-culture generalizability (Ivanova et al., 2007; Rescorla et al., 2007; Rescorla, Achenbach, Ginzburg, & Ivanova, 2007).

This dissertation expands the concept of suicide from “a completed event of ending one’s life” to three categories of behavioral symptoms: suicidal attempts, suicidal ideation and self-injury behavior. The rationale is that all these behavioral symptoms cause or have the potential to cause harm to a child’s life and health, which are highly prevalent among Chinese children (Hesketh, Ding, & Jenkins, 2002; Wan, Hu, Hao, Sun, & Tao, 2011). Table 1.2 lists the operational definitions of childhood BP and their subcategories.
Table 1.2.

The operational definitions of childhood behavior problems

<table>
<thead>
<tr>
<th>Behavior problems</th>
<th>Operational Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Externalizing behaviors</strong></td>
<td>Acts directed to the social environment and characterized by disinhibitory control. These include aggression, delinquency/antisocial behavior and hyperactivity/attention deficit.</td>
</tr>
<tr>
<td><strong>Aggression</strong></td>
<td>Physical or verbal behaviors that harm or threaten to harm others, including children, adults, and animals.</td>
</tr>
<tr>
<td><strong>Delinquency/antisocial behavior</strong></td>
<td>Acts (not including violent acts) that break rules or laws such as lying, cheating, stealing, and committing antisocial acts with bad companions.</td>
</tr>
<tr>
<td><strong>Hyperactivity/Attention Deficit</strong></td>
<td>An excess of motor activity, restlessness or attention deficits in which the children are unable to sustain and modulate their attention in a controlled setting such as the classroom.</td>
</tr>
<tr>
<td>Internalizing behaviors</td>
<td>Negative behaviors directed inward to children themselves. This includes anxiety, depression, somatic complaints and suicide (attempts, ideation or non-suicidal self-injury behavior).</td>
</tr>
<tr>
<td><strong>Anxiety</strong></td>
<td>Symptoms of worry, nervousness and apprehension without cause.</td>
</tr>
<tr>
<td><strong>Depression</strong></td>
<td>Symptoms characterized by excessive sadness and loss of interest in usually enjoyable activities.</td>
</tr>
<tr>
<td><strong>Somatic complaints</strong></td>
<td>Physical symptoms with no identifiable, specific physiological cause.</td>
</tr>
<tr>
<td><strong>Suicide</strong></td>
<td>The act (suicidal attempt) and thoughts (suicidal ideation) of intentionally causing one's own death, or the act of deliberately harming the surface of one’s own body without the intention to end his/her life (self-injury).</td>
</tr>
</tbody>
</table>

*Note.* Definitions were adapted from Liu (2004) and Liu. Chen & Lewis (2011).

**Neurocognition**

Neurocognition is a broad term that refers to a set of higher order mental abilities. It encompasses learning memory, attention, executive function, language, visuoconstructional-perceptual ability, perception of emotions and other aspects that an
individual uses to interact with and make sense of the environment (Roder & Medalia, 2010). Neurocognition is closely linked to brain function (Casey, Tottenham, Liston, & Durston, 2005; Roder & Medalia, 2010). Childhood is the critical period of neurocognitive maturation and exposure to toxic stress during this period can increase the risk of neurocognitive dysfunction or disorders (Korkman, Kemp, & Kirk, 2001; Shonkoff et al., 2012).

Neurocognition can be measured by an individual’s behavioral response to cognitive tasks. For example, the Wechsler Intelligence Scale is one of the most widely used tools in assessing child neurocognition related to verbal comprehension, fluid reasoning, working memory, processing speed, and visual-spatial functioning based on the child’s behavioral responses to a set of tasks. Neurocognition can also be measured by recording brain activities at the neurophysiological level using modern technologies, such as event-related potential (ERP). ERP captures the continuous electrical changes in the brain during neurocognitive processes at an earlier stage before behavioral responses are produced (Hajcak, MacNamara, & Olvet, 2010). It is advantageous due to its non-invasiveness and high temporal resolution. One of the most widely used indicators of neurocognition measured by ERP is P300, which is a positive potential recorded on the scalp that occurs approximately 300ms after the onset of the stimulus, especially when an informative task-relevant or unexpected/infrequent task-irrelevant stimulus is detected (Kim et al., 2001). Specifically, P300 amplitude is believed to reflect selective attention, memory updating and working memory in processing target-relevant or infrequent target-irrelevant stimuli, and P300 latency is regarded as an indicator of evaluation speed to these stimuli that is independent of motor speed (Polich, 2004, 2007).
The Transactional Effect Model

The transactional effect model proposes that child development is a transactional byproduct of the biological genome and epigenome of the child and the external environment, such as the family. Within a certain context, we need to look at both “what the child elicits from the environment and what the child is able to take from the environment” (Sameroff, Fiese, Shonkoff & Meisels, 2000, p.142). This model suggests that developmental outcomes are a complex function of the interplay between child and environment over time. It places emphasis on both the effect of the child on his/her environment and the effect of the environment on the child (Sameroff, 2009; Sameroff & Fiese, 2000).

As applied in research on CM and BP (e.g., Bugental, 2009; Combs-Ronto, Olson, Lunkenheimer, & Sameroff, 2009; Olson & Lunkenheimer, 2009), the transactional effect model suggests that parental maltreating behavior increases the risk of child BP, which is labeled as the parent effect in this dissertation. Child BP may also predispose children to maltreatment by their parents, which is labeled as the child effect in this dissertation based on existing literature (e.g., Combs-Ronto et al., 2009; Klahr, Thomas, Hopwood, Klump, & Burt, 2013; Olson & Lunkenheimer, 2009; Pardini, Fite, & Burke, 2008).

Child Maltreatment and Behavior Problems

A rich body of literature consistently supports the parent effect of CM on BP throughout the life course and across the world (e.g., for reviews, see Fang et al., 2015; Gilbert et al., 2009; Ip et al., 2016; Lindert et al., 2014; Mandelli, Petrelli, & Serretti, 2015; Norman et al., 2012; WHO, 2006). In addition, emerging evidence suggests the
child effect co-exists along with the parent effect. In other words, the relationship between CM and childhood BP is reciprocal rather than unidirectional. For example, Sheehan and Watson (2008) found that among a community sample of 440 children, earlier child aggression predicted increased later maternal aggressive discipline after controlling for earlier maternal aggression towards the child; meanwhile, earlier maternal aggression against children predicted later child aggression. Similarly, Wang and Kenny’s (2014) longitudinal study of 976 middle school students in the United States reported that children’s depressive symptoms and BP at age 13 increased parental use of EA between ages 13 and 14 after adjusting parental EA at age 13. Furthermore, parental EA at age 13 increased children’s depressive symptoms and BP at age 14 after adjusting their depressive symptoms and BP at age 13.

The child effect can be explained as children whose behavior is perceived or misperceived as maladaptive or problematic by parents increase parenting stress and therefore, are more likely to elicit harsh parenting practice (Belsky, 1984). This is consistent with the qualitative findings that both Chinese parents and maltreated children tended to attribute maltreatment to the child’s own misbehaviors or disobedience (Qiao & Xie, 2015; Zhu & Tang, 2012). Also, it is possible that children may exhibit disruptive behaviors to seek attention from their parents even though the attention could be negative (Odhayani, Watson, & Watson, 2013). Additionally, parental BP are associated with their abusive or negligent behaviors towards children (Smith, 2004) and are inheritable to their offsprings (Hicks et al., 2004; Krueger et al., 2002). Therefore, the child effect may be confounded by parents’ own BP. Despite that its underpining is not clear, the child effect
provides a perspective to better understand child/familial characteristics that predispose children to CM.

**Neurocognition in Relation to Child Maltreatment and Behavior Problems**

**The parent effect.** Researchers have proposed many theoretical models to understand the neurocognitive mechanism by which CM increases a child’s vulnerability to BP. For example, Shonkoff et al. (2009, 2012) posited that child maltreatment produces toxic stress that further causes life-long adverse effects on health through changes in neural and biological pathways, especially through the remodeling of brain structure, function, and connectivity. Similarly, Gershoff (2002), Liu & Wuerker (2005) and Liu (2011) also proposed models showing that brain dysfunction mediates the effect of early life health risk factors on later behavior development.

Despite these well-documented theoretical models, the empirical evidence regarding the mediating effect of neurocognition measured by P300 ERP in the relationship between CM and BP is still limited. Only two studies were located, which reported mixed findings. Shackman and colleagues (2007) found that physically abused children exhibited increased P300 amplitude to pictures of their mothers’ angry faces and angry voices, which were further linked to more anxiety symptoms. However, another study conducted by Shackman and Pollak (2014) did not find significant mediation of P300 to negative pictures in the relationship between PA and aggression among 50 boys. The inconsistent findings highlight the need for more studies.

**The child effect.** Though limited, empirical evidence preliminarily supports that neurocognitive dysfunction could increase the risk of CM. Arseneault et al. (2011) reported that low IQ score at age 5 was associated with physical abuse experiences
measured at age 12 among 2,127 British children from a twin cohort. Another longitudinal study in a representative community cohort of children in southeast Michigan showed that a higher IQ measured at age 6 years was associated with a lower risk of exposure to violence and trauma measured at age 17 years, independent of externalizing and internalizing BP (Breslau, Lucia, & Alvarado, 2006). Nevertheless, some studies did not find a significant relationship between IQ and PA (Brown et al., 1998; Young & Widom, 2014).

**Gaps in the Literature**

Despite the abovementioned evidence, there are gaps in the existing literature, notably in Chinese literature. Currently, there is no attempt to pool the empirical findings related to CM and childhood BP in the context of Mainland China. In terms of the parent effect, the neurocognitive mechanism underlying the association between CM and BP remains poorly understood. More specifically, few studies directly examine the mediating effect of P300 to standard auditory stimuli in the relationship between PA and child externalizing behaviors. In terms of the child effect, very little research has examined if neurocognition measured by IQ and child BP in earlier life increases the risk of later parental maltreating behaviors among Chinese children.

The existing literature is also limited in that very few studies attempted to assess child maltreatment practiced by mother and father separately. Empirical studies reported that fathers and mother practiced different parenting styles. Mothering is more emotionally supportive, responsive, and authoritative, whereas fathering is more high-control, less supportive, and authoritarian (Russell, Hart, Robinson, & Olsen, 2003; Tein, Roosa, & Michaels, 1994). In addition, maternal and paternal parenting may be
associated with BP differently (Wang, Wang, & Liu, 2016). Therefore, it is necessary to consider maternal and paternal CM in relation to BP simultaneously, yet separately.

In addition, most studies only use single informant source, either mother or child to collect information of child behavior. Such strategy may not capture the complexity of child behavior comprehensively and are subject to informant bias. Research has suggested that different informants, such as parents, teachers, and children themselves may perceive child behavior differently from each other (Achenbach et al., 1987). However, whether child behavior perceived by different informants (e.g., child, mothers and teachers) is associated with CM equally or differently needs further investigation.

**Theoretical Framework**

Based on the transactional effect model (Sameroff, 1975, 2009; Sameroff & Fiese, 2000) and the existing findings in the literature, a theoretical framework was developed to address both the parent effect and the child effect (Figure 1.1). The parent effect model (1A) illustrates that PA increases the risk of children’s BP through neurocognitive dysfunction, such as altered P300 amplitude and latency. The child effect model (1B) proposes that neurocognitive dysfunction, such as low verbal and performance IQ and BP predisposes children to high risk of being physically abused.

In the parent effect model, the mediating effect of neurocognitive dysfunction is proposes to be partial considering that there may be other potential pathways linking PA to BP. In the child effect model, this dissertation intended to provide initial evidence of potential neurocognitive and behavioral risk factors for later PA. Exploration of more complicated mediating mechanisms that neurocognitive dysfunction leading to PA
through BP, or the interactive effect of neurocognitive dysfunction and BP on PA are beyond the scope of this dissertation.

Figure 1.1. The theoretical framework of this dissertation study: the relationships among child physical abuse, behavior problems, and neurocognitive dysfunction. 1A, the parent effect model. 1B, the child effect model.

**Purpose and Specific Aims**

The purpose of this dissertation was to examine the relationships among CM, BP, and neurocognition among children in the context of Mainland China to provide a deeper understanding of their complex interrelations. The first aim was to estimate the mean effect size of the relationship between three forms of CM (i.e., PA, EA, and neglect) and childhood BP (the parent effect) in Mainland China. This aim was addressed through completing a meta-analysis of relevant studies conducted among children in Mainland China in Chapter 2.

The second aim was to test the mediating effect of neurocognition measured by P300 ERP in the relationship between PA and externalizing behaviors informed by the
parent effect model (see Chapter 3). This aim was achieved through a quantitative secondary analysis of existing data from a sub-cohort of children (n=155) in the China Jintan Child Cohort Study in Chapter 3. PA, BP and P300 were measured cross-sectionally in 2013. The hypotheses tested for this aim were:

Hypothesis 2.1): Physically abused children by either their fathers or mothers had neurocognitive dysfunction as indicated by altered P300 amplitude and latency of ERP during a standard novel auditory oddball task.

H 2.2): Physically abused children exhibited more externalizing BP.

H 2.3): Altered P300 amplitude and latency mediated the relationship between PA and externalizing BP.

The third aim was to examine the risk effects of neurocognitive dysfunction as measured by IQ and BP in earlier life on later PA guided by the child effect model (see Chapter 4). This aim was achieved by a quantitative secondary analysis of existing data from a prospective-designed sub-cohort (n=265) in China Jintan Child Cohort Study in Chapter 4. More specifically, IQ and BP were measured during 2010–2012 and PA was measured in 2013. The hypothesis tested for this aim was that low IQ (verbal and performance) and more BP perceived by mothers and teachers predicted more child physical abuse 1-3 years later.

The meta-analysis focused on the three types of CM to obtain a broad understanding of the relationship between CM and childhood BP. The two quantitative sub-studies for the second and third aims solely focused on PA (occurred or not regardless of intensity or chronicity). The sub-studies in Chapters 3 and 4 used two
different indicators of neurocognition (P300 ERP in Chapter 3 and IQ in Chapter 4) due to different study aims.

**Summary and Significance**

Given the large child population and the high prevalence of CM in Mainland China, an extremely large number of Chinese children suffer from CM. Yet, CM that does not result in severe injuries or death remains an acceptable practice and receives little attention in Mainland China. This study aimed to test the relationships among CM, BP, and neurocognition. The findings contribute to our knowledge of the pooled relationships between CM and childhood BP in the context of Mainland China. In addition, this dissertation provides a deeper understanding of the neurocognitive mechanism underlying the relationship between PA and BP informed by the parent effect model, and the potential neurocognitive and behavioral risk factors for PA guided by the child effect model. These findings provide empirical evidence that can be used to increase public awareness of the adverse effects of CM on childhood BP and to develop tailored intervention for at-risk children. The findings can also be used to urge public health agencies in Mainland China to put forth more effort into building an effective and implementable system to protect children from CM at societal, community, family and individual levels to promote child neurocognitive and behavioral health.
References


contributions of temperament and parenting styles. *International Journal of Behavioral Development, 27*(1), 74-86.


CHAPTER 2: PHYSICAL ABUSE, EMOTIONAL ABUSE, AND NEGLECT AND
CHILDHOOD BEHAVIOR PROBLEMS: A META-ANALYSIS OF STUDIES
IN MAINLAND CHINA

Abstract
The relationship between three types of child maltreatment, including physical abuse, emotional abuse and neglect and childhood behavior problems in Mainland China have not been systematically examined. This meta-analysis reviewed findings from 42 studies conducted in 98,749 children in Mainland China and analyzed the pooled effect sizes of the associations between child maltreatment and childhood behavior problems, heterogeneity in study findings and publication bias. In addition, this study explored cross-study similarities/differences by comparing the pooled estimates with findings from five existing meta-analyses. Equivalent small-to-moderate effect sizes emerged in the relationships between the three types of maltreatment and child externalizing and internalizing behaviors, except that emotional abuse related more to internalizing than externalizing behaviors. Considerable heterogeneity exists among the 42 studies. Weak evidence suggests that child gender and reporter of emotional abuse may moderate the strengths of the relationships between child maltreatment and behavior problems. No indication of publication bias emerged. Cross-study comparisons show that the pooled effect sizes in this meta-analysis are about equal to those reported in the five meta-analyses conducted in child and adult populations across the world. Findings urge relevant agencies in Mainland China to build an effective child protection system to prevent child maltreatment.

Keywords: child maltreatment, behavior, China, meta-analysis, cross-study comparison
# Table of Key Abbreviations

<table>
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<th>Domain</th>
<th>Abbreviations</th>
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<td><strong>Child Maltreatment</strong></td>
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<td>CM</td>
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<td>EXTER</td>
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<td><strong>Relationships</strong></td>
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<td>CM–BP</td>
<td>Relationship between child maltreatment and behavior problems</td>
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<td>EA–EXTER</td>
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<td>CTQ</td>
<td>Childhood Trauma Questionnaire</td>
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<td>CTSPC</td>
<td>Parent–child Conflict Tactics Scale</td>
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<td>OR</td>
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<td>RR</td>
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<td>URR</td>
<td>Usable Return Rate</td>
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Introduction

Child maltreatment (CM), especially physical abuse (PA), emotional abuse (EA) and neglect are highly prevalent in Mainland China. Researchers estimated that in China, 1 in 3 Chinese experienced PA, 1 in 5 experienced EA and 2 in 5 experienced neglect in their childhood (Fang et al., 2015; Ji & Finkelhor, 2015). In particular, the prevalence of PA is higher in Mainland China (40.6%) is higher than the estimated prevalence in other Chinese societies (19.5%; Ji & Finkelhor, 2015) and the pooled estimate globally (17.7%; Stoltenborgh, Bakermans-Kranenburg, IJzendoorn, & Alink, 2013).

Accumulating evidence shows that CM by parents, guardians, or family members relates to aggressive and violent behaviors, depression, anxiety, and suicide in Chinese societies (for reviews, see Dunne, Chen, & Wan Yuen, 2008; Fry, McCoy, & Swales, 2012; Gershoff et al., 2010; Kwok, Chai, & He, 2013; Wong, Leung, Chow, Kam, & Tang, 2010). However, existing systematic reviews or meta-analyses in the Chinese context are limited in several ways. First, they focused on studies conducted in child and adult populations and failed to differentiate between them. Childhood BP is a major risk factor for adulthood crime, violence, and mental disorders (Leschied, Chiodo, Nowicki, & Rodger, 2008; Reef, Diamantopoulou, van Meurs, Verhulst, & van der Ende, 2011). Investigation of childhood BP related to CM is informative for prevention of BP at an earlier life stage. Second, whether different types of child maltreatment relate to different BP equally or differently is unknown. Third, many possible factors that could contribute to the heterogeneity in relationships between CM and BP have not been analyzed in the existing meta-analyses. For example, emerging evidence shows that child and parent
gender matter in the relationship between child maltreatment and behavior problems (Xing, Wang, Zhang, He, & Zhang, 2011; Xing & Wang, 2013); however, whether child or parental gender moderates the average effect size of the association of CM and BP is unclear. Last, the cross-study similarities and differences in the pooled estimates of the associations between CM and BP among existing meta-analyses has not been examined.

The primary objective of the present meta-analysis was to estimate the effect size of the relationships between three types of CM, including PA, EA, and neglect, and childhood BP. Childhood BP refers to child externalizing (EXTER) and internalizing behaviors (INTER) and their subtypes, including aggression, delinquency/antisocial behavior, hyperactivity/attention deficit, anxiety, depression, somatic complaints, and suicidal attempts, suicidal ideation, and self-injury behavior (Liu, 2004; Liu, Chen, & Lewis, 2011). In addition, the meta-analysis also (1) examined whether different types of maltreatment relate to different behavior problems equally or differently, (2) tested the heterogeneity in study findings and the contributions of sample characteristics and methodological factors to it, and (3) explored cross-study similarities/differences by comparing findings with those in recent existing meta-analyses.

Methods

Literature Search

A computerized literature search was conducted using the two largest Chinese databases (CNKI: the Chinese National Knowledge Infrastructure, Wanfang Data) and three English databases (PubMed, PsychoInfo, and Scopus) in May 2016. Chinese and English
search terms related to CM (i.e., child maltreatment, child abuse, victimization, trauma, neglect, emotional abuse, psychological abuse, physical abuse, or physical punishment), BP (i.e., externalizing behaviors, internalizing behaviors, aggression, violence, crime, delinquency, antisocial behavior, hyperactive, attention deficit, anxiety, depression, somatic, suicide attempt, suicidal ideation or self-injury) and Mainland China were used.

The search was restricted to English or Chinese language, but not restricted to any time period. Reference lists of eligible articles and five review articles (i.e., Dunne et al., 2008; Fang et al., 2015; Fry et al., 2012; Ip et al., 2015; United Nations Children’s Fund, 2014) were also examined to identify additional relevant publications.

A separate computerized literature search was conducted in Scopus to identify recent existing meta-analyses on the relationship of CM and BP using the terms described above and meta-analysis in January 2017 and time period restricted to 2012 and beyond.

**Eligibility Criteria and Study Selection**

To meet inclusion criteria for this meta-analysis, studies had to (1) be quantitative original research, (2) include children under 18 years old (i.e., maximum age or one standard deviation above mean age was below 18 years old, or participants were from senior high school\(^3\) or lower if age range or mean was not reported) from Mainland China, and (3) have the independent variable of CM and the dependent variable of BP meet the definitions described in Table 2.1. Studies were excluded if they (1) focused

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\(^3\) Mainland China has a very structured education system. The primary school (Grades 1-6) and junior high school (grades 7-9) are mandatory. Children usually start primary school at age 6-8 years and finish senior high school by age 18 years.
solely on child sexual abuse or collapsed sexual abuse with other types of maltreatment into one category, (2) presented CM as dependent variable, (3) used data that were duplicated in another article, or (4) did not provide sufficient information in articles directly or through contact with the authors to calculate effect sizes.

To meet the inclusion criteria for the cross-study comparison, meta-analyses must (1) focus on the relationship between at least one of the three types of CM (i.e. PA, EA or neglect) and BP, (2) have comparable definitions of CM and BP with those in the present meta-analysis, and (3) have available information of pooled estimates of effect size and their confidence intervals.

Data Extraction and Coding

Two raters screened the search results independently based on the eligibility criteria. Disagreements were resolved by consensus to reduce bias and errors (Buscemi, Hartling, Vandermeer, Tjosvold, & Klassen, 2006). After obtaining all eligible studies, we used the first author’s last name and publication year to identify each study. Based on the literature, we extracted the following data from each study using the codebook in Appendix A.

(1) Publication type (peer-reviewed journal article, conference paper or thesis/dissertation).

(2) Sample characteristics, including sample size (large if \(n\geq 1,000\), otherwise small), percentage of girls, age (mean and standard deviations, or age range or grade if mean age
was unreported), study region (Northeast, Central, Southwest, Northwest, North, South, East, multiple regions or unspecified, Zhou et al., 2015), residential areas⁴ (rural, urban or mixed if participants were from both rural and urban areas), and response rate ([RR] the number of usable responses returned divided by the total number eligible in the sample chosen) or usable return rate ([URR] the number of usable responses returned divided by the total number of questionnaires distributed) if RR was unreported.

(3) Methodological factors, including study design (cross-sectional or longitudinal), sampling methods (probability sampling or not), subgroups (e.g., girls or boys, father report or mother report), number of study sites (single site or multiple sites), validated assessment of CM (yes or no), CM assessment tool (CTSPC: Parent–child Conflict Tactics Scale, CTQ: Childhood Trauma Questionnaire, self-developed instrument or others), CM reporter (child, parent, or others), CM perpetrator (father, mother, parents if the parental gender was not specified, or mixed with parents, guardians and family members) and BP measurement (questionnaire, diagnosed or other). These factors may contribute to the heterogeneity in study findings and hence, were used as moderators separately (Ji & Finkelhor, 2015).

Information of CM (PA, EA, neglect or mixed) and BP (Level-1 coding: EXTER, INTER or mixed if EXTER and INTER were not differentiated; Level-2 coding: aggression, delinquency/antisocial behavior, hyperactivity/attention deficit, anxiety, depression, somatic complaints, suicidal attempts, suicidal ideation, self-injury behavior) and

⁴ This is defined by if the participants were from urban or rural areas. In China, rural residents are officially different from urban residents because rural residents hold farmer resident cards.
information to calculate effect sizes were also collected. Missing information was requested from authors, and was coded as missing if it could not be obtained. Additionally, after obtaining eligible existing meta-analyses, information regarding CM types, BP types, pooled effect sizes and confidence intervals of the relationship between CM and BP were also extracted.

**Quality Assessment**

The same two raters appraised the quality of each study using the modified Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies (Appendix B) based on each study’s objective(s), sampling description, measurement, and analysis. Each item is worth one point and a higher summed score indicates better study quality. Study quality was regarded as high if the point sum was higher than half of the total number of items that applied to the study. Otherwise, it was rated as low. Disagreements in the assessment between the raters were resolved by consensus.

**Statistical analysis**

*Calculation of effect sizes*

To calculate the effect size for each study, Cohen’s $d$ was first calculated from bivariate correlation coefficients, unadjusted odds ratios, means and standard deviations, or frequencies and/or proportions. Then, Hedges’s $g$ was calculated from Cohen’s $d$ multiplying $J$, where

$$J = 1 - \left( \frac{3}{4(N - 2) - 1} \right)$$
to correct for potential bias introduced by studies with small sample sizes \((N)\) to estimate the effect size of each study. Similar to Cohen’s \(d\), Hedges’s \(g = 0.2\) is considered a small effect size, 0.5 represents a medium effect size and 0.8 a large effect size (Lipsey & Wilson, 2001).

Effect sizes within a study were averaged in the following cases when necessary: 1) studies that reported two or multiple Level-2 BP by the same participants that can be categorized into the same Level-1 BP, 2) studies that assessed multiple conditions of a single type of CM (e.g. PA reported by fathers and mothers separately, information about mild PA and severe PA separately), and 3) longitudinal studies that reported cross-sectional CM–BP relationships at multiple time points. The variance of the averaged effect size was calculated using

\[
\text{var} \left( \frac{1}{m} \sum_{i=1}^{m} Y_i \right) = \left( \frac{1}{m} \right)^2 \text{var} \left( \sum_{i=1}^{m} Y_i \right) = \left( \frac{1}{m} \right)^2 \left( \sum_{i=1}^{m} V_i + \sum_{i \neq j}^{m} (r_{ij} \sqrt{V_i} \sqrt{V_j}) \right)
\]

as described in Borenstein, Hedges, Higgins, & Rothstein (2009), where \(Y_i\) denotes the effect sizes from different BP outcomes, CM conditions or time points within a study, \(Y_i\) has the variance \(V_i\) for several variables \(i=1,\ldots, m\), and \(r_{ij}\) is the correlation between \(Y_i\) and \(Y_j\). When \(r_{ij}\) was not reported in the study, correlation equal to 1 was used.

Considering that only two studies reported the longitudinal relationships between CM and BP and the remaining studies were cross-sectional, the effect sizes of all the cross-sectional relationships were submitted to analyze the pooled estimates across studies,
moderator effects, and publication bias. Sensitivity analysis was conducted by adding the
effect sizes from the longitudinal relationships.

Separate meta-analyses using random-effects model (DerSimonian & Kacker, 2007) were
run for each type of CM and each type of BP at the two levels. The differences in the
associations of each type of CM and each BP were first identified if their 95% confidence
intervals (CI) were not overlapped and then tested using \( Q \) statistics (Higgins, Thompson,
Deeks, & Altman, 2003).

\textit{Heterogeneity}

Firstly, heterogeneity across studies was identified by the \( I^2 \) statistic that was calculated
for each pooled estimate to determine the proportion of the observed variance that
reflects variance in true effect sizes. \( I^2 \) Values < 25\%, 50\%, and \( \geq 75\% \) represent low,
moderate, and high levels of heterogeneity, respectively (Higgins, Thompson, Deeks, &
Altman, 2003).

Next, heterogeneity among studies due to the categorical moderators was estimated using
the \( Q \) statistic. Meta-regression was used to estimate the possible effect of mean age, RR
or URR on the CM–BP relationship. Because the number of studies reporting information
for boys and girls separately was small, the effect of child gender was analyzed in two
ways: (1) meta-regression using the proportion of girls as the independent variable, and
(2) \( Q \) statistics comparing the effect sizes in boy and girl subgroups respectively, using
studies that reported such information.
Publication bias

Publication bias was estimated using three methods, the classic fail-safe \( N \), funnel plot and the trim-and-fill method. The classic fail-safe \( N \) calculates the number of potential unpublished studies with insignificant findings that would be needed to reduce the pooled effect size in the meta-analysis below the level of significance. A file-drawer effect, selective publication bias, exists when the fail-safe \( N \) is less than five times the number of published studies plus ten (Rosenthal, 1979). A funnel plot is a plot of the effect sizes in studies included in meta-analysis against their standard errors (Sterne & Egger, 2001). It is expected to be symmetrical. An asymmetrical funnel plot might arise if larger studies with non-significant results or with an effect size in the non-hypothesized direction are preferentially published while smaller studies with such findings are less likely to be published (Sterne & Egger, 2001). Based on the funnel plot, the trim and fill method imputes the missing effect sizes to fill in asymmetrical areas of the funnel plot and then recalculate the overall effect size to test publication bias (Duval & Tweedie, 2000).

Sensitivity analysis

A series of sensitivity analyses were conducted to test the uncertainty in the study findings. For studies without information about the correlations among multiple BP outcomes or CM conditions, the variance of the average effect size was recalculated using correlations of 0 and 0.5, respectively, and then all analyses were rerun. Next, all analyses were rerun after adding in the longitudinal relationship between CM and BP.
Finally, the CM–BP relationships were tested in the high and low study quality subgroups, respectively.

*Converting effect sizes in the eligible existing meta-analyses*

The pooled effect sizes and confidence intervals were converted to Cohen’s $d$ if other forms (e.g. odds ratio, risk ratio) of effect sizes were reported in the eligible meta-analyses to ensure comparability.

All the formulae employed in these analyses but not displayed can be found in Lipsey & Wilson (2001). Comprehensive Meta-Analysis v3 (Biostat, Englewood, NJ) was used to complete the meta-analysis.

**Results**

*Study Selection*

The literature search yielded a total of 4,466 unique citations; 4,313 were excluded after title and abstract screening. Of the remaining 153 articles, 105 were further excluded upon full-text screening based on the eligibility criteria. One additional eligible article was identified from the reference list of a retrieved article. This process resulted in 46 articles from 42 studies that met the eligibility criteria (Figure 2.1). Articles from the same study were identified based on the author names, study location, and sample characteristics, and were coded as one study if they focused on different CM or BP.

*Study Characteristics*
The 42 studies were conducted among 98,749 children with an average mean age of 12.13 years and an average of 48.7% girls in all the seven regions of Mainland China. Among the 42 studies, 34 were peer-reviewed publications, 7 were theses/dissertations and one was conference paper. Nineteen studies had sample sizes over 1,000. Sixteen studies used probability sampling methods. Eleven studies reported RR (>90% in 8 studies), 17 studies reported URR (>90% in 16 studies), while 14 studies did not specify RR or URR. Fourteen studies recruited samples from both rural and urban areas, two from rural areas only, two from urban areas only, and the remaining 24 did not specify this information.

The majority of studies were cross-sectional; two were longitudinal. Almost all studies were conducted in multiple sites; three studies did not specify study site. Nine studies used the CTSPC, six used the CTQ to assess CM, five used self-developed instruments and the remaining 22 studies used other tools. Nine studies collected CM data reported by parents, while the remaining studies used child-report data. Four studies reported the CM–BP relationships for boys and girls, respectively. Four studies differentiated father abuser and mother abuser. Eight studies collected CM information from parents, while the remaining used child-report CM data. All studies measured BP using questionnaires.

The numbers of studies regarding PA–EXTER, PA–INTER, EA–EXTER, EA–INTER, neglect–EXTER, and neglect–INTER relationships were 10, 13, 8, 16, 7, and 15, respectively; six studies focused on mixed CM or mixed BP in their study without differentiating their types or subtypes. Twenty-one and twenty studies were classified as
high and low quality, respectively. The study quality of Li et al. (2016) were evaluated for the two subsamples separately (one was classified as high and the other was low).

In addition, two studies reported information specific to left-behind children (children who were left at home for a long period with their extended family members by their parents who migrate to urban areas to work); therefore, a code to indicate left-behind children or not was added to capture this unique phenomenon in Mainland China.

**Physical Abuse**

Among all the studies that examined PA–EXTER relationships, all but one study reported increased EXTER in relation to PA, Hedges’s $g=0.503$ (95% CI: 0.358–0.649). All studies but one examining PA–INTER relationships reported increased INTER related to PA, Hedges’s $g=0.493$ (95% CI: 0.469–0.518). The two studies that reported relationships between PA and mixed BP showed a small effect size, Hedges’s $g=0.376$ (95% CI: 0.330–0.422). The separate analyses for the relationships between PA and each Level-2 BP showed similar small-to-medium effect sizes. All the 95% CIs were overlapped, indicating there were not significant differences in the relationships between PA and Level-1 or -2 BP. See Figure 2.2 and Table 2.3.

**Emotional Abuse**

Among all the studies focused on EA–EXTER relationships, all but one study reported increased EXTER in relation to EA. The pooled estimate Hedges’s $g=0.348$ (95% CI: 0.150–0.547). All studies on EA–INTER relationship reported positive relationships and
the pooled estimate was 0.592 (95% CI: 0.489–0.695). One study on EA and mixed BP relationship reported a large effect size, Hedges’s $g=0.874$ (95% CI: 0.750–0.998). The effect size of EA–INTER relationship was larger than that of EA–EXTER ($Q=5.961$, $p=0.015$). Specifically, the associations of EA with Level-2 BP, including depression, self-injury behavior and somatic complaints were higher than that of EA with aggression ($p$ values <0.05). See Figure 2.3 and Table 2.3.

**Neglect**

The majority of studies on neglect–EXTER and neglect–INTER relationships reported neglected children had more EXTER and INTER except for five studies. The pooled estimates for neglect–EXTER and neglect–INTER were 0.266 (95% CI: 0.087–0.444) and 0.460 (95% CI: 0.340–0.580), respectively. These were not significantly different. Neglect was also associated with all Level-2 BP about equally. See Figure 2.4 and Table 2.3.

**Mixed Child Maltreatment**

All studies that examined the relationship between CM without differentiating its subtypes reported increased EXTER (Hedges’s $g=0.713$, 95% CI: 0.436–1.989) and INTER (Hedges’s $g=0.626$, 95% CI=0.260–0.902) equally. See Figure 2.5 and Table 2.3.

**Heterogeneity**

Despite some exceptions, there was substantial heterogeneity among most of the studies regarding CM–BP relationships evidenced by the majority of $I^2$ values >75% ($p$
Child gender

Meta-regression analysis did not find a significant linear relation between the proportion of girls and CM–BP relationships. A further analysis using the four studies that reported information stratified by child gender revealed that the PA–EXTER relationship was stronger among girls (Hedges’s $g=0.935$, 95% CI= 0.712–1.160) than boys (Hedges’s $g=0.568$, 95% CI= 0.354–0.781), $Q=5.443$, $p=0.020$. The EA–INTER association was stronger among boys (Hedges’s $g=0.651$, 95% CI=0.584–0.718) than girls (Hedges’s $g=0.507$, 95% CI=0.447–0.567), $Q=9.835$, $p=0.002$.

Reporter of CM

The effect size of EA–INTER relationship in one study that used parent-report EA (Hedges’s $g=0.191$, 95% CI= -0.059–0.441) was smaller than the pooled estimate of this relationship in the 14 studies that used child-report EA data (Hedges’s $g=0.632$, 95% CI=0.554–0.709), $Q=10.920$, $p=0.001$.

Sensitivity Analyses

The same analyses were rerun using variance of the average effect sizes among multiple outcomes/conditions calculated from correlations of 0 and 0.5, respectively. These analyses produced equivalent results. The results remained unchanged after adding the
effect sizes of the longitudinal relationships. The effect sizes of CM–BP relationships did not significantly differ between high and low study quality subgroups.

Publication Bias

The present meta-analysis did not find evidence of publication bias. The funnel plots were symmetrical (Figure 2.6). The Fail-safe $N$ numbers were very large to reduce the mean effect size below the level of significance for the PA–EXTER ($N=845$), PA–INTER ($N=3,500$), EA–EXTER ($N=582$), EA–INTER ($N=8,190$), neglect–EXTER ($N=171$), and neglect–INTER ($N=2,366$) relationships. The trim-and-fill method did not identify any missing studies for these relationships.

Cross-study Comparison

Five meta-analyses (Ip et al., 2016; Lindert et al., 2014; Mandelli, Petrelli, & Serretti, 2015; Norman et al., 2012; Wilson, Norris, Shi, & Rack, 2010) were identified and compared with the present findings. As shown in Table 2.4, the point estimates (Hedges’s $g$) in the present meta-analysis were slightly higher than those (Cohen’s $d$) in the five meta-analyses conducted in child or both child and adult populations across the world. However, all 95% CIs overlapped.

Discussion

Findings from the 42 studies conducted among 98,749 Chinese children supported the hypothesis that PA, EA and neglect by parents, guardians and other family members in the household are undoubtedly associated with a broad spectrum of BP in childhood. The
pooled estimates suggest that different types of CM relate to different types of BP approximately equally, with small-to-moderate effect sizes, except that EA related more to INTER than EXTER. Moderator analysis showed that child gender and reporter of CM may contribute to the heterogeneity among study findings but the evidence is still weak. No indication of publication bias emerged. In addition, the cross-study comparison showed that the present findings are equivalent to findings from the five identified meta-analyses conducted in child and adult populations across the world.

**Pooled Estimates of Effect size**

The present meta-analysis found that all three types of CM related to a broad spectrum of childhood BP, including EXTER and INTER in Mainland China. This is consistent with evidence that CM may be a non-specific risk factor for health problems due to its universal adverse effects on multiple biological, neurological and epigenetic pathways underlying behavioral, mental and physical health problems (Irving et al., 2013; McCrory, De Brito, & Viding, 2010; Vachon et al., 2015).

The estimated small-to-moderate effect sizes were considered as of practical significance. Methodologically, public health, social and psychological studies are more likely to produce smaller effect sizes due to attenuation in validity of measures in comparison to studies with good experimental control like clinical random trials (McCartney & Rosenthal, 2000). Empirically, they are of practical importance because of the high economic burden and the long-term adverse consequences related to CM and childhood BP. Based on the modest associations of PA and EA with mental health problems in
China, Fang et al. (2015) estimated that the economic cost of PA and EA was 0.47% and 0.84% of the gross domestic product (i.e., about US$27 and US$50 billion, respectively) in 2010. Also, childhood EXTER and INTER are major risk factors for many social, societal and health outcomes such as adulthood crime, violence and mental disorders (for meta-analyses, see Leschied et al., 2008; Reef et al. 2011).

**Heterogeneity**

Considerable heterogeneity exists among study findings. Although most of predetermined sample characteristics and methodological factors did not significantly contribute to heterogeneity, weak evidence emerged that child gender may contribute to heterogeneity. This notion was supported in the literature that CM and BP are not equally prevalent in boys and girls (Cui, Xue, Connolly, & Liu, 2016; Liu, 2004; Liu et al., 2011), and that child gender affects the strength of their relationships (Braza et al., 2015). In addition, parent-report EA showed different strength of relationship with INTER from child-report EA. This could be because Chinese parents and children have discrepant perceptions of EA (Chan, 2012), but the exact explanation needs more studies to clarify.

**Cross-study Comparison**

The positive relationship between CM and more EXTER and INTER in Chinese children is consistent with findings from five recent meta-analyses conducted in a variety of populations from different countries and regions. The point estimates of the pooled effect size in the present study were consistently and slightly larger than the estimates in the other five meta-analyses, especially regarding PA and EA. This outcome may be because
PA and EA are more prevalent in Mainland China than in most other countries (Fang et al., 2015; Ji & Finkelhor, 2015; Stoltenborgh, Bakermans-Kranenburg, Alink, & van IJzendoorn, 2012; Stoltenborgh et al., 2013), or that CM–BP relationships are relatively stronger in child populations than adult populations. All studies included in the present meta-analysis measured BP using subjective questionnaires rather than diagnostic standards, whereas other meta-analyses included studies using diagnostic BP as outcomes. Therefore, measurement error introduced by subjective measures may contribute to the difference. Also, it is possible that effect sizes calculated from unadjusted estimates in the present meta-analysis may produce larger effect sizes than other meta-analyses with effect sizes calculated from estimates that were adjusted for covariates (Norman et al., 2012). Nevertheless, the 95% CI overlapped across all meta-analyses, indicating that the observed differences were not significant. The cross-study comparison provided initial evidence of the equal strength of CM–BP relationships across populations and countries. Researchers can make greater effort to directly compare similarities and differences in the relationship between CM and BP across social, cultural and societal contexts using comparable methodology.

**Limitations**

Findings should be interpreted cautiously in light of study limitations. First, considerable variations exist in how researchers defined and measured PA, EA and neglect across the 42 studies. As discussed in the five existing meta-analyses, the present meta-analysis found that some studies defined PA using multiple specific parental violent behaviors such as hitting, beating and kicking (e.g., Kwok, Chai, & He, 2013; Tang et al., 2011),
whereas others simply referred to “physical punishment” or “being hit” (Hesketh et al., 2011; Liu, Sun, & Yang, 2008). Some studies (e.g., Ge et al., 2013; Tao et al., 2006; Yu et al., 2013; Zhang et al., 2013) may have excluded physical abuse in its mild form that are conventionally accepted as ordinary discipline but still related to BP (Gershoff, 2002). EA was measured by public humiliation (Olson et al., 2011), verbal abuse (Liu et al., 2008), or multiple behaviors including both and threatening to hit (e.g., Liu et al., 2012; Pan et al., 2005; Tao et al., 2006). The majority of studies on neglect applied the Child Psychological Abuse and Neglect Scale (CPANS) developed by Chinese researchers based on the CTQ, the CTSPC, and the Chinese sociocultural context, and assessed physical, psychological and educational neglect (Liu & Nian, 2012; Yang, 2012), whereas others applied the CTQ and only measured psychological and physical neglect.

Second, child participants in the 42 studies were diverse in gender, age, and geographic region. However, they were relatively homogenous considering that all were students attending regular schools in the regions where Han Chinese people populate. Attention is still needed for disadvantaged children who do not attend regular schools (e.g., disabled or critically ill children who reside at home or in special education schools), and children in the 55 minority ethnic groups in Mainland China.

Third, the review focused on studies using CM as the independent variable and BP as the dependent variable. However, all studies but two were cross-sectional. Hence, no causal relationship can be inferred and the possibility that BP increases the risk of CM should not be ruled out.
Fourth, the moderator analyses for child gender, reporter of child maltreatment and maltreatment by fathers and mothers were performed only in a limited number of studies. Therefore, the estimate may be not precise enough to draw any conclusion. Future studies should stratify analysis by child and parent gender and collect CM from children and from parents to generate more evidence.

Lastly, the present meta-analysis calculated effect sizes using the unadjusted rather than adjusted relationship between CM and BP because estimate adjusting covariates may be affected by possible mediating mechanisms which will downwardly bias estimates of the overall effect of child maltreatment. It is possible that the relationship can change after adjusting for confounding variables, especially co-occurring maltreatment, family dysfunction and parental behavioral and mental health (Norman et al., 2012).

Conclusion

This meta-analysis contributes to the existing literature by examining the associations between PA, EA, and neglect and childhood BP in the Mainland China context. Findings showed CM was undoubtedly related to a broad spectrum of childhood BP among Chinese children. The associations of different types of CM and different types/subtypes of childhood BP were about equivalent. In addition, associations between CM and BP in Mainland Chinese children were equal to the estimates in some existing meta-analyses of studies of child and adult populations across the world. Child protection persists as a concern in Mainland China because China lacks an implemented and effective child-protection system and CM does not receive much attention (Man, Barth, Li, & Wang,
2017). Our findings provide empirical evidence that it is urgent and important to build an effective child-protection system and launch evidence-based programs for the prevention of CM and childhood BP in Mainland China.
References

* indicates articles included in the meta-analysis


*Li, P. (2013). *Relational aggression, self-supporting personality, and psychological abuse and neglect.* (Master), Qufu Normal University, Shandong, China.


*Wan, Y. (2015). The role of pain processing in the relationship between childhood physical abuse and non-suicidal self-injury behaviors among middle school students. (PhD), Anhui Medical University, Anhui, China.


*Xu, T. (2015). The research about parents harsh discipline and children's temperament and behavior problems. (Master), Shanxi University, Shanxi, China.


Zhou, X., Zhu, F., Li, J., Mao, W., Zhang, D... Cai, J. (2015). Geographic regions of China. Northeast China (NE), North China (NC), Northwest China (NW), East China (EC), Central China (CC), South China (SC), and Southwest China (SW). Retrieved from https://figshare.com/articles/_Geographic_regions_of_China_Northeast_China_NE_North_China_NC_Northwest_China_NW_East_China_EC_Central_China_CC_South_China_SC_and_Southwest_China_SW_/1560916.


Table 2.1. Definitions of child maltreatment and behavior problems in the meta-analysis

<table>
<thead>
<tr>
<th>Terms</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child maltreatment</td>
<td>All forms of physical and/or nonphysical abuse, neglect or negligent treatment by parents, guardians or other family members in the household resulting in actual or potential harm to the child’s health, survival, development or dignity. The meta-analysis focuses on its three forms: physical abuse, emotional abuse, and neglect.</td>
</tr>
<tr>
<td>Physical abuse</td>
<td>The physical force against a child by parents, guardians or other family members in the household that results in or has a high likelihood of resulting in harm to the child’s health, survival, development or dignity. This includes hitting, beating, kicking, shaking, biting, strangling, scalding, burning, poisoning, suffocating, and other violent acts.</td>
</tr>
<tr>
<td>Emotional abuse</td>
<td>Non-physical forms of rejection or hostile treatment by parents, guardians or other family members that may have a high probability of damaging the child’s physical or mental health, or the child’s physical, mental, spiritual, moral or social development, such as the restriction of movement, belittling, blaming, threatening, frightening, discriminating against, humiliating or ridiculing.</td>
</tr>
<tr>
<td>Neglect</td>
<td>Failure to provide for the development and well-being of the child in health, education, emotional development, nutrition, shelter or safe living conditions by parents, guardians or other family members.</td>
</tr>
<tr>
<td>Externalizing behaviors</td>
<td>Acts directed to the social environment and characterized by disinhibitory control. These include aggression, delinquency/antisocial behavior and hyperactivity/attention deficit.</td>
</tr>
<tr>
<td>Aggression</td>
<td>Physical or verbal behaviors that harm or threaten to harm others, including children, adults, and animals.</td>
</tr>
<tr>
<td>Delinquency/antisocial behavior</td>
<td>Acts (not including violent acts) that break rules or laws such as lying, cheating, stealing, and committing antisocial acts with bad companions.</td>
</tr>
<tr>
<td>Hyperactivity/Attention Deficit</td>
<td>An excess of motor activity, restlessness or attention deficits in which the children are unable to sustain and modulate their attention in a controlled setting such as the classroom.</td>
</tr>
<tr>
<td>Internalizing behaviors</td>
<td>Negative behaviors directed inward to children themselves. These include anxiety, depression, somatic complaints and suicide (attempts, ideation or non-suicidal self-injury behavior).</td>
</tr>
<tr>
<td>Anxiety</td>
<td>Symptoms of worry, nervousness, and apprehension without cause.</td>
</tr>
<tr>
<td>Depression</td>
<td>Symptoms characterized by excessive sadness and loss of interest in usually enjoyable activities.</td>
</tr>
<tr>
<td>Somatic complaints</td>
<td>Physical symptoms with no identifiable, specific physiological cause.</td>
</tr>
<tr>
<td>Suicide</td>
<td>The act (suicidal attempt) and thoughts (suicidal ideation) of intentionally causing one's own death, or the act of deliberately harming the surface of one’s own body without the intention of causing death (self-injury).</td>
</tr>
</tbody>
</table>

Notes. The definitions of child maltreatment, physical abuse, emotional abuse and neglect were adapted from World Health Organization (2006, p. 9-10). The definitions of externalizing and internalizing behaviors and their subtypes were adapted from Liu (2014) and Liu et al. (2011).
<table>
<thead>
<tr>
<th>Study No.</th>
<th>Study Name</th>
<th>Region</th>
<th>Sample Size</th>
<th>Age (years)</th>
<th>Gender (% Girls)</th>
<th>Probability Sampling</th>
<th>RR/URR</th>
<th>Child Maltreatment: Measurement</th>
<th>Behavior Problem: Measurement</th>
<th>Study Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chang et al. (2003)</td>
<td>SC</td>
<td>325</td>
<td>4.6±1.0</td>
<td>44.6</td>
<td>NC</td>
<td>NC</td>
<td>Mixed (PA &amp; EA) by father and mother, respectively: PARQ (FR, MR)</td>
<td>Aggression: sdi (TR)</td>
<td>Low</td>
</tr>
<tr>
<td>2</td>
<td>Chen (2015)</td>
<td>NE (Heilongjiang)</td>
<td>1,113</td>
<td>Middle School grade1-4</td>
<td>50.6</td>
<td>NO</td>
<td>95.62</td>
<td>EA and Neglect: CPANS</td>
<td>Depression: CES_D</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Cheng et al. (2010)</td>
<td>EC (Jiangxi)</td>
<td>223 LBC</td>
<td>12.3±2.0</td>
<td>49.0</td>
<td>YES</td>
<td>99.4</td>
<td>EA and Neglect: CPANS</td>
<td>Hyperactivity, INTER, EXTER: SDQ</td>
<td>High</td>
</tr>
<tr>
<td>4</td>
<td>Du et al. (2014)</td>
<td>unspecified</td>
<td>393</td>
<td>11.0±1.2</td>
<td>52.4</td>
<td>YES</td>
<td>91.4</td>
<td>Neglect: CPANS</td>
<td>EXTER behavior: RCBQ (PR)</td>
<td>High</td>
</tr>
<tr>
<td>5</td>
<td>Eisenberg et al. (2009)</td>
<td>NC (Beijing &amp; Hebei)</td>
<td>697</td>
<td>8.3±0.6</td>
<td>44.5</td>
<td>NC</td>
<td>NC</td>
<td>PA: PSDQ (PR)</td>
<td>EXTER and INTER: sdi (TR)</td>
<td>Low</td>
</tr>
<tr>
<td>6</td>
<td>Gao et al. (2016)</td>
<td>SC (Guangdong)</td>
<td>1,163</td>
<td>13.8±1.0</td>
<td>43.3</td>
<td>YES</td>
<td>NC</td>
<td>Mixed (PA &amp; EA): CTSPC</td>
<td>Delinquency and Depression: sdi</td>
<td>High</td>
</tr>
<tr>
<td>7</td>
<td>Ge et al. (2013), Yu et al. (2013) &amp; Zhang et al. (2013)</td>
<td>EC (Anhui)</td>
<td>1,417</td>
<td>14.3±1.3</td>
<td>46.6</td>
<td>NO</td>
<td>98.5</td>
<td>PA and EA: sdi</td>
<td>Aggression: BPAQ, Delinquency: sdi</td>
<td>Low</td>
</tr>
<tr>
<td>8</td>
<td>Hesketh et al. (2011)</td>
<td>EC (Zhejiang)</td>
<td>2,203</td>
<td>7-12</td>
<td>43.7</td>
<td>YES</td>
<td>80</td>
<td>PA: sdi</td>
<td>EXTER and INTER: RCBQ</td>
<td>High</td>
</tr>
<tr>
<td>9</td>
<td>Kwok et al. (2013)</td>
<td>EC (Shanghai)</td>
<td>560</td>
<td>14.0±1.2</td>
<td>47.2</td>
<td>NO</td>
<td>NC</td>
<td>PA and EA: CTSPC</td>
<td>Suicidal Ideation: C-SIS</td>
<td>High</td>
</tr>
<tr>
<td>10</td>
<td>Lansford et al. (2005)</td>
<td>NC (Beijing)</td>
<td>50</td>
<td>10.6±1.9</td>
<td>46.0</td>
<td>NO</td>
<td>NC</td>
<td>PA: interview (Child and MR)</td>
<td>Aggression and Anxiety: YSR and CBCL (MR)</td>
<td>Low</td>
</tr>
<tr>
<td>11</td>
<td>Lansford et al. (2014)</td>
<td>EC (Shandong &amp; Shanghai)</td>
<td>239</td>
<td>8.3±0.6</td>
<td>51.0</td>
<td>NO</td>
<td>NC</td>
<td>PA: interview (MR)</td>
<td>Aggression and Anxiety/Depression: YSR and CBCL (MR)</td>
<td>Low</td>
</tr>
<tr>
<td>12</td>
<td>Li (2013)</td>
<td>NC</td>
<td>647</td>
<td>Middle school</td>
<td>52.4</td>
<td>NC</td>
<td>93.0</td>
<td>EA and Neglect: CPANS</td>
<td>Aggression: MCP</td>
<td>Low</td>
</tr>
<tr>
<td>13</td>
<td>Li et al. (2012)</td>
<td>EC (Shandong)</td>
<td>816</td>
<td>14.6±2.1</td>
<td>52.2</td>
<td>YES</td>
<td>NC</td>
<td>Neglect: CTQ</td>
<td>EXTER, Hyperactivity, and INTER: SDQ</td>
<td>High</td>
</tr>
<tr>
<td>Study No.</td>
<td>Study Name</td>
<td>Region</td>
<td>Sample Size</td>
<td>Age (years)</td>
<td>Gender (% Girls)</td>
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<td>RR/URR</td>
<td>Child Maltreatment: Measurement</td>
<td>Behavior Problem: Measurement</td>
<td>Study Quality</td>
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</tr>
<tr>
<td>14</td>
<td>Li et al. (2016)</td>
<td>NC, EC, &amp; SE</td>
<td>259 Control: 269</td>
<td>9.6±1.6 Control: 9.1±1.5</td>
<td>NO</td>
<td>ODD: 84.9 Control: NC</td>
<td>PA and EA: CTQ (PR)</td>
<td>Aggression: CBS (TR)</td>
<td>ODD, High Control: Low</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Liu et al. (2008)</td>
<td>EC (Shandong)</td>
<td>1,920</td>
<td>13.6±1.7</td>
<td>45.2</td>
<td>YES</td>
<td>NC</td>
<td>PA, EA and Neglect: sdi</td>
<td>Suicidal Attempt</td>
<td>High</td>
</tr>
<tr>
<td>16</td>
<td>Liu et al. (2012)</td>
<td>EC (Shandong)</td>
<td>1,070</td>
<td>13.8</td>
<td>52.1</td>
<td>YES</td>
<td>91.9</td>
<td>PA and EA by father and mother: CTSPC</td>
<td>EXTER: YSR</td>
<td>Low</td>
</tr>
<tr>
<td>17</td>
<td>Liu et al. (2016)</td>
<td>EC (Anhui)</td>
<td>5,116</td>
<td>15.8±1.9</td>
<td>45.7</td>
<td>YES</td>
<td>94.7</td>
<td>Neglect: CTQ</td>
<td>Suicidal Attempt and Suicidal Ideation</td>
<td>Low</td>
</tr>
<tr>
<td>18</td>
<td>Liu &amp; Nian (2012)</td>
<td>NE (Heilongjiang)</td>
<td>503</td>
<td>9.7±0.9</td>
<td>49.9</td>
<td>NO</td>
<td>96.3</td>
<td>Neglect: CPANS</td>
<td>Aggression: MCP</td>
<td>High</td>
</tr>
<tr>
<td>19</td>
<td>Luo et al. (2013)</td>
<td>CC (Hunan)</td>
<td>940</td>
<td>8-12</td>
<td>49.9</td>
<td>NO</td>
<td>83.9</td>
<td>EA and Neglect: CPANS</td>
<td>Somatic: CSI</td>
<td>High</td>
</tr>
<tr>
<td>20</td>
<td>Ma et al. (2011)</td>
<td>SC (Guangdong)</td>
<td>3,037</td>
<td>13.4±0.5</td>
<td>49.9</td>
<td>YES</td>
<td>96.1</td>
<td>PA: CTSPC</td>
<td>Depression: DSRSC</td>
<td>High</td>
</tr>
<tr>
<td>21</td>
<td>Olson et al. (2011)</td>
<td>NC (Beijing)</td>
<td>59</td>
<td>4.4±0.3</td>
<td>45%</td>
<td>NC</td>
<td>96.70</td>
<td>Mixed (PA &amp; EA): SOMA-PP (PR)</td>
<td>EXTER: CBCL/1.5-5</td>
<td>Low</td>
</tr>
<tr>
<td>22</td>
<td>Pan (2010)</td>
<td>CC (Hunan)</td>
<td>7,248</td>
<td>7-17</td>
<td>46.9</td>
<td>YES</td>
<td>94.8</td>
<td>EA: CPANS</td>
<td>Anxiety: SCARED</td>
<td>Depression: DSRSC</td>
</tr>
<tr>
<td>23</td>
<td>Su et al. (2015)</td>
<td>SW (Guizhou)</td>
<td>4,617</td>
<td>15.2±1.8</td>
<td>54.1</td>
<td>YES</td>
<td>96.0</td>
<td>Neglect: CTQ</td>
<td>Self-harm: sdi</td>
<td>High</td>
</tr>
<tr>
<td>25</td>
<td>Tang et al. (2011) &amp;</td>
<td>SC (Guangdong)</td>
<td>6,593</td>
<td>14.2±1.0</td>
<td>49.9</td>
<td>YES</td>
<td>99.5</td>
<td>PA: CTSPC</td>
<td>BPmixed: sdi Suicidal Ideation: sdi Somatic: sdi</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Wong et al. (2009)</td>
<td></td>
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<tr>
<td>26</td>
<td>Tao et al. (2006)</td>
<td>EC (Anhui)</td>
<td>5,141</td>
<td>15.0±1.6</td>
<td>48.3</td>
<td>NO</td>
<td>94.3</td>
<td>PA and EA: sdi</td>
<td>Anxiety: SCL-90 Depression: SCL-90 Somatic: SCL-90 Self-Injury: sdi</td>
<td>Low</td>
</tr>
<tr>
<td>27</td>
<td>Wan (2015)</td>
<td>CC (Henan), SW (Guizhou), &amp; EC (Anhui)</td>
<td>14,820</td>
<td>15.4±1.8</td>
<td>50.2</td>
<td>NC</td>
<td>95.6</td>
<td>Neglect: CTQ</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Study No.</td>
<td>Study Name</td>
<td>Region</td>
<td>Sample Size</td>
<td>Age (years)</td>
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<td>Behavior Problem: Measurement</td>
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<tr>
<td>28</td>
<td>Wan et al. (2014)</td>
<td>SC (Guangdong), CC (Henan), NC (Liaoning), &amp; SW (Chongqing)</td>
<td>14,211</td>
<td>15.1±1.9</td>
<td>52.8</td>
<td>NO</td>
<td>96.9</td>
<td>PA and EA: sdi</td>
<td>Self-Injury: sdi</td>
<td>Low</td>
</tr>
<tr>
<td>29</td>
<td>Wang et al. (2008)</td>
<td>CC (Henan)</td>
<td>355</td>
<td>16.2±1.1</td>
<td>56.3</td>
<td>YES</td>
<td>88.7(^\text{U})</td>
<td>EA and Neglect: CPANS</td>
<td>Depression: SDS</td>
<td>High</td>
</tr>
<tr>
<td>30</td>
<td>Wang et al. (2016)</td>
<td>EC (Shandong)</td>
<td>1,971</td>
<td>7-17</td>
<td>49.4</td>
<td>NO</td>
<td>95.80</td>
<td>PA and EA by father and mother: CTSPC (FR)</td>
<td>Anxiety: SCAS (FR, MR)</td>
<td>Low</td>
</tr>
<tr>
<td>31</td>
<td>Wu et al. (2011)</td>
<td>CC (Hunan)</td>
<td>1,555</td>
<td>13.1±1.1</td>
<td>45.3</td>
<td>NO</td>
<td>96.9</td>
<td>EA: CPANS</td>
<td>Conduct: SDQ Hyperactivity: SDQ INTER: SDQ</td>
<td>High</td>
</tr>
<tr>
<td>32</td>
<td>Xiao et al. (2008)</td>
<td>EC (Anhui)</td>
<td>10,894</td>
<td>15.4±2.0</td>
<td>47.5</td>
<td>NO</td>
<td>NC</td>
<td>PA and EA: sdi</td>
<td>Self-Injury: sdi</td>
<td>Low</td>
</tr>
<tr>
<td>33</td>
<td>Xing et al. (2011, 2013)</td>
<td>EC</td>
<td>486 at T1, and 454 at T2</td>
<td>10.7±1.0</td>
<td>49.8</td>
<td>NC</td>
<td>NC</td>
<td>PA: CTSPC</td>
<td>Aggression: YSR Delinquency: YSR Anx/Dep: YSR</td>
<td>High</td>
</tr>
<tr>
<td>34</td>
<td>Xu (2015)</td>
<td>NW (Shanxi)</td>
<td>597</td>
<td>5.1±0.8</td>
<td>48.2</td>
<td>NO</td>
<td>96.3</td>
<td>PA and EA: CTSPC (FR, MR)</td>
<td>BPmixed: RCBQ (PR)</td>
<td>High</td>
</tr>
<tr>
<td>35</td>
<td>Yang (2012)</td>
<td>CC (Hubei)</td>
<td>324</td>
<td>Elementary school grade 3-6</td>
<td>36.1</td>
<td>NO</td>
<td>92.6</td>
<td>EA and Neglect: CPANS</td>
<td>Anxiety: SCS</td>
<td>High</td>
</tr>
<tr>
<td>36</td>
<td>Zhang &amp; Guo (2003)</td>
<td>SW (Sichuan)</td>
<td>1,393</td>
<td>15.0±2.0</td>
<td>51.5</td>
<td>YES</td>
<td>98.0(^\text{U})</td>
<td>Mixed (PA &amp; EA): ASLEC suicidal ideation: sdi</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Zhang et al. (2008)</td>
<td>CC (Henan)</td>
<td>258</td>
<td>15.2±1.7</td>
<td>57.7</td>
<td>YES</td>
<td>NC</td>
<td>Mixed (EA &amp; Neglect): CPANS</td>
<td>Aggression: AAQ</td>
<td>Low</td>
</tr>
<tr>
<td>38</td>
<td>Zhao et al. (2014)</td>
<td>E (Anhui)</td>
<td>2,917 LBC and non-LBC</td>
<td>7-17</td>
<td>47.4</td>
<td>YES</td>
<td>NC</td>
<td>PA and Neglect: CTSPC</td>
<td>Anxiety: SAS</td>
<td>High</td>
</tr>
<tr>
<td>39</td>
<td>Zhou et al. (2004)</td>
<td>N (Beijing)</td>
<td>425</td>
<td>7.7±0.6</td>
<td>55.5</td>
<td>NO</td>
<td>72.20</td>
<td>PA and EA: PSDQ (PR)</td>
<td>EXTER: CBCL (PR)</td>
<td>High</td>
</tr>
<tr>
<td>40</td>
<td>Zhu et al. (2010)</td>
<td>S (Guangxi)</td>
<td>659</td>
<td>Middle school grade 1-3</td>
<td>52.8</td>
<td>NO</td>
<td>NC</td>
<td>EA and Neglect: CPANS</td>
<td>Depression: CES_D</td>
<td>High</td>
</tr>
<tr>
<td>41</td>
<td>Zhu et al. (2013)</td>
<td>S (Guangxi)</td>
<td>866</td>
<td>11.4±1.0</td>
<td>49.4</td>
<td>NO</td>
<td>97.4(^\text{U})</td>
<td>Neglect: CTQ</td>
<td>Anxiety: SAS</td>
<td>High</td>
</tr>
<tr>
<td>42</td>
<td>Zou et al. (2012)</td>
<td>CC (Henan)</td>
<td>74</td>
<td>14.2±0.7</td>
<td>0</td>
<td>NO</td>
<td>NC</td>
<td>PA: CECAQ EA and neglect by father and mother: CECAQ</td>
<td>Aggression: AQ Aggression: AQ</td>
<td>Low</td>
</tr>
</tbody>
</table>
Notes. NC: unspecified or unclear. ODD: Oppositional Defiant Disorder. LBC: Left-behind children, defined as children who were left at home for a long period with their extended family members by their parents who migrate to urban areas to work. Left-behind children are a unique phenomenon in Mainland China.

In column 3, CC: Central China; EC: East China; NC: North China; NE: Northeast China; NW: Northwest China; SC: South China; and SW: Southwest China. Geographical regions can be visualized in Zhou et al. (2015).

In column 8, RR: response rates, were calculated by dividing the number of usable responses returned by the total number eligible in the sample chosen. URR: usable return rates, indicated by superscript U, were calculated by dividing number of usable responses returned by the total number of questionnaires distributed.

In columns 9 and 10, delinquency is short for delinquency/antisocial behavior; hyperactivity is short for hyperactivity/attention deficit; Somatic is short for somatic complaints; Anx/Dep refers to combined anxiety and depression.


Child maltreatment measurement tools: ASLEC: Adolescent Self-Rating Life events checklist; CECAQ: Childhood Experience of Care and Abuse Questionnaire; CPANS: Child Psychological Abuse and Neglect Scale; CTQ: Childhood Trauma Questionnaire; CTSPC: Parent–child Conflict Tactics Scale; PARQ: Parental Acceptance Rejection Questionnaire; PSDQ: Parenting Styles and Dimensions; SOMA-PP: Socialization of Moral Affect questionnaire-Preschool Parent. sdi, self-developed instrument.

Child behavior problems measurement tools: AAQ: Adolescent Aggression Questionnaire; AQ: Aggression Questionnaire; BPAQ: Buss-Perry Aggression Questionnaire; CBCL: Child Behavior Checklist; CBS: Child Behavior Scale; CDI: Children’s Depression Inventory; CES_D: Center for Epidemiological Survey Depression Scale; CSI: Children's Somatization Inventory; DSRSC: Depression Self-rating Scale for Children; MCP: Mastery Class Play; RCBQ: Rutter Child Behavior Questionnaire; RCP: Revised Class Play; SAS: Self-rated Anxiety Scale; SASC: The Social Anxiety Scales for Children; SCARED: The Screen for Child Anxiety Related Emotional Disorders; SCAS: Spence Children’s Anxiety Scale; SCS: Child Self-Concept Scale; SDQ: Strength and Difficulties Questionnaire; SDS: Self-rating Depression Scale; SIS: Suicidal Ideation Subscale; STDS: State Depression Scale in the State-Trait Depression Scale; YSR: Youth Self Report. sdi, self-developed instrument.

In study 14, the ODD and control groups were treated as two independent samples.

The CTQ measured five types of CM including physical abuse, emotional abuse, sexual abuse, physical neglect and emotional neglect in childhood. Only data related to emotional neglect was included in the analysis because the abusers of the other types might include people other than parents, guardians or family members in the household.
## Table 2.3. The pooled estimates of effect size and heterogeneity ($I^2$) from the meta-analysis

<table>
<thead>
<tr>
<th></th>
<th>Physical Abuse</th>
<th></th>
<th>Emotional Abuse</th>
<th></th>
<th>Neglect</th>
<th></th>
<th>Mixed Child Maltreatment</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n$</td>
<td>$g$</td>
<td>(95% CI)</td>
<td>$I^2$</td>
<td>$n$</td>
<td>$g$</td>
<td>(95% CI)</td>
<td>$I^2$</td>
</tr>
<tr>
<td><strong>Externalizing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical Abuse</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical Abuse</td>
<td>10</td>
<td>0.503</td>
<td>(0.358, 0.649)</td>
<td>77.6</td>
<td>8</td>
<td>0.466</td>
<td>(0.422, 0.510)</td>
<td>94.5</td>
</tr>
<tr>
<td>Physical Abuse</td>
<td>10</td>
<td>0.480</td>
<td>(0.319, 0.640)</td>
<td>80.9</td>
<td>8</td>
<td>0.232</td>
<td>(0.062, 0.402)</td>
<td>84.7</td>
</tr>
<tr>
<td>Physical Abuse</td>
<td>2</td>
<td>0.559</td>
<td>(0.291, 0.827)</td>
<td>82.5</td>
<td>2</td>
<td>0.568</td>
<td>(0.013, 1.123)</td>
<td>94.7</td>
</tr>
<tr>
<td>Physical Abuse</td>
<td>0</td>
<td>NA</td>
<td></td>
<td></td>
<td>2</td>
<td>0.519</td>
<td>(0.003, 1.036)</td>
<td>92.4</td>
</tr>
<tr>
<td><strong>Internalizing</strong></td>
<td>13</td>
<td>0.493</td>
<td>(0.469, 0.518)</td>
<td>92.6</td>
<td>16</td>
<td>0.583</td>
<td>(0.562, 0.604)</td>
<td>94.5</td>
</tr>
<tr>
<td>Internalizing</td>
<td>5</td>
<td>0.496</td>
<td>(0.353, 0.639)</td>
<td>78.0</td>
<td>3</td>
<td>0.746</td>
<td>(0.321, 1.172)</td>
<td>96.0</td>
</tr>
<tr>
<td>Internalizing</td>
<td>2</td>
<td>0.531</td>
<td>(0.112, 0.949)</td>
<td>91.4</td>
<td>7</td>
<td>0.631</td>
<td>(0.432, 0.829)</td>
<td>95.8</td>
</tr>
<tr>
<td>Internalizing</td>
<td>3</td>
<td>0.336</td>
<td>(-0.05, 0.723)</td>
<td>93.9</td>
<td>0</td>
<td>NA</td>
<td>1</td>
<td>0.524</td>
</tr>
<tr>
<td>Internalizing</td>
<td>2</td>
<td>0.466</td>
<td>(0.052, 0.881)</td>
<td>87.1</td>
<td>2</td>
<td>0.663</td>
<td>(0.441, 0.884)</td>
<td>57.0</td>
</tr>
<tr>
<td>Internalizing</td>
<td>2</td>
<td>0.836</td>
<td>(0.235, 1.438)</td>
<td>88.3</td>
<td>2</td>
<td>0.561</td>
<td>(0.336, 0.786)</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Notes.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delinquency</td>
<td>3</td>
<td>0.402</td>
<td>(0.325, 0.479)</td>
<td>13.5</td>
<td>2</td>
<td>0.564</td>
<td>(0.335, 0.794)</td>
<td>69.8</td>
</tr>
<tr>
<td>Suicide Attempt</td>
<td>3</td>
<td>0.599</td>
<td>(0.543, 0.655)</td>
<td>87.1</td>
<td>3</td>
<td>0.586</td>
<td>(0.550, 0.623)</td>
<td>8.4</td>
</tr>
<tr>
<td>Self-Injury</td>
<td>2</td>
<td>0.376</td>
<td>(0.330, 0.422)</td>
<td>99.1</td>
<td>1</td>
<td>0.874</td>
<td>(0.750, 0.998)</td>
<td>NA</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXTER</td>
<td>0.503 (0.358, 0.649)</td>
<td>0.242 (0.005, 0.478)</td>
<td></td>
<td></td>
<td>0.290 (-0.467, 1.047)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delinquency</td>
<td>0.559 (0.291, 0.827)</td>
<td></td>
<td>0.242 (0.005, 0.478)</td>
<td></td>
<td>0.360 (0.284, 0.436)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anxiety</td>
<td>0.496 (0.353, 0.639)</td>
<td>0.374 (0.084, 0.664)</td>
<td>0.293 (0.156, 0.429)</td>
<td></td>
<td></td>
<td>0.238 (0.083, 0.393)</td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td>0.531 (0.112, 0.949)</td>
<td>0.286 (0.169, 0.403)</td>
<td>0.22 (0.141, 0.299)</td>
<td>0.377 (0.286, 0.467)</td>
<td>0.238 (0.083, 0.393)</td>
<td></td>
<td>0.675 (0.428, 0.922)</td>
</tr>
<tr>
<td>Suicidal Attempts</td>
<td>0.836 (0.235, 1.438)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>EA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td>0.631 (0.432, 0.829)</td>
<td></td>
<td></td>
<td>0.564 (0.351, 0.777)</td>
<td>0.617 (0.49, 0.744)</td>
<td>0.189 (0.058, 0.32)</td>
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</tr>
<tr>
<td>Delinquency</td>
<td>0.568 (0.013, 1.123)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suicidal Attempts</td>
<td>0.561 (0.336, 0.786)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Neglect</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXTER</td>
<td>0.266 (0.087, 0.444)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.300 (-0.289, 0.889)</td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td>0.823 (0.580, 1.066)</td>
<td></td>
<td></td>
<td></td>
<td>0.558 (0.257, 0.859)</td>
<td>0.412 (0.263, 0.561)</td>
<td></td>
</tr>
<tr>
<td>Delinquency</td>
<td>0.616 (0.187, 1.046)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.412 (0.263, 0.561)</td>
<td></td>
</tr>
<tr>
<td>Suicidal Attempts</td>
<td>0.281 (0.090, 0.472)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.368 (0.066, 0.67)</td>
<td></td>
</tr>
</tbody>
</table>

Notes. Ip et al. (2015) used 24 studies of Chinese children and adults in Chinese societies, including Mainland China, Taiwan, Hong Kong, Macau, and Singapore.
Lindert et al. (2014) used 19 articles about child and adult studies in 14 countries around the world, including one Chinese study conducted in Beijing and Shanghai.
Mandelli et al. (2015) used 26 adult studies conducted in the United States, Canada, European countries and South American countries.
Norman et al. (2012) used 124 studies conducted in child and adult populations across the world, with the majority conducted in the United States.
Wilson et al. (2010) used child studies conducted in the United States, Canada and Spain.
CM: Child maltreatment; PA: physical abuse; EA: emotional abuse; BP: behavior problems; EXTER: externalizing behaviors. Delinquency is short for delinquency/antisocial behavior.
The present study reported Hedges’s $g$ as the effect size, whereas the effect sizes of the other five meta-analyses were Cohen’s $d$. For studies reporting odds ratios (ORs), ORs were converted to Cohen’s $d$ using relevant formulae described in Lipsey and Wilson, 2001. Hedges’s $g$ and Cohen’s $d$ are almost identical for large studies, whereas Hedges’s $g$ is generally smaller than Cohen’s $d$ in studies with relatively small sample sizes.

Blank cells indicate corresponding relationship was not examined in corresponding meta-analysis.
Figure 2.1. A diagram for the steps of article search and selection for the meta-analysis.

CNKI, China National Knowledge Infrastructure
Figure 2.2. Forest plot of the association of child physical abuse (PA) and externalizing (EXTER), internalizing (INTER) and mixed behavior problems ([MixedBP] refers to both externalizing and internalizing behaviors). The Square shape and bar line represents the estimate of effect size and 95% confidence interval for each study, respectively. The diamond shapes represent the pooled estimates of the effect sizes for different behavioral outcomes. Favours B indicates that child maltreatment increases behavior problems, while Favours A indicates child maltreatment decreases behavior problems.
Figure 2.3. Forest plot of the associations of child emotional abuse (EA) and externalizing (EXTER), internalizing (INTER) and mixed behavior problems ([MixedBP] refers to both externalizing and internalizing behaviors). The Square shape and bar line represents the estimate of effect size and 95% confidence interval for each study, respectively. The diamond shapes represent the pooled estimates of the effect sizes for different behavioral outcomes. Favours B indicates that child maltreatment increases behavior problems, while Favours A indicates child maltreatment decreases behavior problems.
Figure 2.4. Forest plot of the associations of child neglect and externalizing (EXTER) and internalizing (INTER). The Square shape and bar line represents the estimate of effect size and 95% confidence interval for each study, respectively. The diamond shapes represent the pooled estimates of the effect sizes for different behavioral outcomes. Favours B indicates that child maltreatment increases behavior problems, while Favours A indicates child maltreatment decreases behavior problems.
Figure 2.5. Forest plot of the associations of mixed child maltreatment ([MIXED] refers to combined multiple types of child maltreatment) and externalizing (EXTER) and internalizing (INTER). The Square shape and bar line represents the estimate of effect size and 95% confidence interval for each study, respectively. The diamond shapes represent the pooled estimates of the effect sizes for different behavioral outcomes. Favours B indicates that child maltreatment increases behavior problems, while Favours A indicates child maltreatment decreases behavior problems.
Figure 2.6. Funnel plots of the included studies. A: Studies of physical abuse and externalizing behaviors; B: Studies of physical abuse and internalizing behaviors; C: Studies of emotional abuse and externalizing behaviors; D: Studies of emotional abuse and internalizing behaviors; E: Studies of neglect and externalizing behaviors; F: Studies of neglect and internalizing behaviors; G: All studies included in the meta-analysis.
CHAPTER 3: CHILD PHYSICAL ABUSE AND EXTERNALIZING BEHAVIORS: MEDIATING EFFECT OF P300 EVENT-RELATED POTENTIALS

Abstract

This study aimed to examine the association of child physical abuse with P300 event-related potentials (ERP), and to test the mediating effect of P300 amplitude and latency in the relationship between child physical abuse and externalizing behaviors. Cross-sectional secondary data are from 155 children (55.5% boys, mean age: 11.28±0.57 years) who participated in the China Jintan Child Cohort Study. The following data were obtained in 2013: maternal and paternal physical abuse, externalizing behaviors reported by child, mother and teacher, and P300. Additionally, parents and teachers reported child externalizing behaviors in preschool in 2007. P300 were recorded during a standard novel auditory oddball task. Path analysis shows that children with maternal physical abuse showed increased novelty P300 amplitude when controlling for child sex, socioeconomic status, family location, IQ, and externalizing behaviors in preschool. Novelty P300 amplitude mediated the relationship between maternal physical abuse and self-report externalizing behaviors. These findings suggest that physically abused children tend to exhibit externalizing behaviors because they allocate more attentional resources to novel/deviant events in the environment.

Keywords: child physical abuse, P300, event-related potential, externalizing behaviors, mediation
Introduction

The relationship between child physical abuse and behavior problems across cultures has been well documented in the literature (Fry, McCoy, & Swales, 2012; Gershoff, Lansford, Sexton, Davis-Kean, & Sameroff, 2012; Kawabata, Alink, Tseng, Van Ijzendoorn, & Crick, 2011). Yet, not all maltreated children develop behavior problems, which raises the question of the mechanism underlying the associations between child physical abuse and behavior problems. Altered neurocognitive development related to child physical abuse may be a potential pathway leading to behavior problems (McCrorry, De Brito, & Viding, 2010, 2011, 2012; McGinn, Cukor, & Sanderson, 2005). This is supported by the empirical evidence of the mediating effect of neurocognition measured by neuropsychological tasks in the relationship between authoritarian parenting style or physical maltreatment and externalizing behaviors (Chang, Olson, Sameroff, & Sexton, 2011; Eisenberg, Chang, Ma, & Huang, 2009; Xing, Wang, and Wang, 2016; Zhou, Eisenberg, Wang, & Reiser, 2004).

At the neurophysiological level, P300 Event-related Potential (ERP) is a widely-used proxy of allocation of neural resources and neurocognitive processing capability (Polich, 2004, 2007). P300 has two properties: amplitude and latency. P300 amplitude is regarded as an indicator of selective attention, memory updating and working memory in processing target relevant or rare target-irrelevant with events in the environment. P300 latency is thought to reflect stimulus evaluation speed that is independent of motor processing speed (Polich, 2004, 2007). The major advantage of ERP over laboratory neuropsychological tasks in measuring neurocognition is its high temporal resolution in
reflecting continuous electrical changes in the brain during the neurocognitive process that is independent of behavioral responses, such as reaction time and accuracy in neurobehavioral tasks (Hajcak, MacNamara, & Olvet, 2010).

Only two studies examining the mediating effect of P300 in the relationship between physical abuse and child behavior problems were found. Shackman and colleagues (2007) reported that physically abused children exhibited increased P300 amplitude to threatening stimuli (i.e. their mother’s angry faces and angry voices), and such features further linked to more anxiety symptoms. Findings from a subsequent study by Shackman and Pollack (2014) found that physical abuse increased P300 amplitude for angry faces, and, however, the latter did not significantly correlate with child aggression in 15 boys. The inconsistent findings in these studies may be attributed to the differences in the participant characteristics (e.g. both boys and girls vs. boys only and age difference), modality (both visual and vocal stimuli from children’s own mothers vs. visual stimuli from unfamiliar adults) and behavioral outcomes (anxiety reported by parents using a questionnaire vs. aggression measured objectively using an aggression task). Moreover, the non-statistical-significant finding in Shackman & Pollak (2014) may be because of the small sample size to detect significant relationship between P300 and aggression. Therefore, larger-scale studies using a standard task protocol to elicit P300 are necessary to further investigate the relationships among physical abuse, P300 and child externalizing behaviors.

The objectives of this study were two-fold: 1) to test the relationship between child physical abuse and P300 elicited by a standard novel auditory oddball task stimuli,
and 2) to examine the mediating effect of P300 amplitude and latency to novel and target stimuli in the relationship between child physical abuse and externalizing behaviors using secondary data from a community sample of Chinese children from the China Jintan Cohort study. In this cohort study, child physical abuse perpetrated by mothers and fathers were measured separately. Also, child externalizing behaviors were rated by multiple informants, namely children, mothers and teachers to account for the situational specificity of child behavior (Achenbach, McConaughy, & Howell, 1987).

Methods

Design and Participants

This study used cross-sectional secondary data collected from a sub-cohort (n=414) of children during the Wave II (T2) of the China Jintan Child Cohort Study, which is an ongoing prospective study (Liu et al., 2015; Liu, McCauley, et al., 2011; Liu, McCauley, Zhao, Zhang, & Pinto-Martin, 2010). These sub-cohort children were initially recruited when they were about 3 years old in preschool in 2004–2005. All children were invited to participate in the two waves of data collection: 1) T1 in 2007 when they were in preschool (~ 6 years old), and 2) T2 in 2013 when they were in Grade 6 elementary school (~ 12 years old). The original sub-cohort was regarded as representative of children of the same age in Jintan City, a small-scale city on the east coast in Mainland China. The details of cohort design and sampling information are described elsewhere (Liu et al., 2015; Liu, McCauley, et al., 2011; Liu et al., 2010). This study was approved by the Institutional Review Board (IRB) of the University of Pennsylvania and the Ethics Committee of the Jintan Hospital.
Measurements

Child Physical Abuse

At T2, children reported their physical abuse experiences using the severe physical assault subscale in the Chinese Version of The Parent–Child Conflict Tactics Scale (CTSPC, Straus et al., 1998). They were asked to provide information on whether they were 1) hit on body parts besides the bottom with objects, 2) thrown or knocked down, 3) hit with a fist or kicked hard, 4) beaten up, 5) grabbed around the neck and choked, 6) burned or scalded on purpose, or 7) threatened with a knife or other weapons by their mothers and fathers separately in the preceding year (0=“No”, or 1=“Yes”). Children who answered “Yes” to at least one of these items were regarded as physical abuse survivors. The CTSPC has good construct validity (Straus et al., 1998). The Chinese version of CTSPC showed satisfactory to good reliabilities in Chinese studies (Chan, 2012; Cui, Xue, Connolly, & Liu, 2016). In the present study, the Cronbach’s alpha coefficients for maternal (0.84) and paternal (0.87) physical abuse were acceptable. Out of the 414, 335 children filled out the questionnaire.

Psychophysiological Assessment

Standard Novel Auditory Oddball Task. The oddball paradigm is a well-known standard paradigm to elicit P300 responses recorded by ERP. The oddball task used in this study contains 280 high- (non-target, presented at 1000 Hz) and 35 low-pitched tones (target, presented at 500 Hz), as well as 35 novel tones (e.g., dog-bark bell, bird, honk) at 75 dB and lasting for 150 ms, with an inter-stimulus interval of 1.1s, an inter-trial interval of
1.25s and rise and fall times of 5ms. The target, non-target, and novel tones were presented in random order. The duration of the task was 7.5 minutes.

Children were tested in a temperature-controlled, light- and sound-attenuated laboratory, with a computer screen placed at a distance of 1 meter. For the duration of the task, the children were instructed to keep their eyes fixated on an “X” on the computer screen. To ensure they could distinguish between the non-target and target tones before the actual test, they were allotted time to complete 6 practice trials. In the actual test, they were instructed to press a response button as quickly as possible with their dominant hand in response to the target tones, but not to the non-target or novel ones. The number and reaction time of correct responses to target, and the number of incorrect responses to non-target (commission error) and novel stimuli (false alarm) were recorded as indicators of behavioral performances.

**ERP Recording and Data Acquisition.** During the oddball task, electroencephalography (EEG) was recorded from an Electro-Cap (Eaton, OH) with tin (Sn) electrodes placing at 12 sites on the scalp (FP1, FP2, F3, F4, F7, F8, P3, P4, T3, T4, O1, and O2) according to the International 10-20 system. A single-channel EEG100C biopotential module (BIOPAC Systems, Inc., Goleta, CA) was used to amplify the EEG signal from each electrode. Signal from the linked earlobes via 9 mm Sn cup electrodes were used as the reference for the EEG signal. The recording was grounded via 8 mm diameter silver/silver chloride (Ag/AgCl) electrodes attached to the distal phalanges of the first and second fingers of the non-
dominant hand, which also recorded the skin conductance in the parent study.

Impedance for EEG was kept below 10 kΩ and was under 5 kΩ for most participants. Data from EEG channels were recorded using a bandpass of 0.01–35 Hz and a 50 Hz notch filter, with a 1000 Hz sampling rate and gain set to 5000. More details of the EEG recording was described in Rudo-Hutt (2015).

After ERP recording, data from each EEG channel were visually inspected in AcqKnowledge (BIOPAC Systems Inc., Goleta, CA), and artifactual data due to equipment failure or excessive movements were discarded. The EEG data was further processed by removing remaining artifacts using custom scripts in MATLAB (MathWorks Inc., Natick, MA). Next, the cleaned EEG data was divided into epochs based on stimulus presentation (from 200 ms before to 800 ms after each stimulus) and averaged over all trials and all electrodes for each stimulus type (target, non-target, and novel) in MATLAB to generate the P300 (i.e. the greatest positive deflection post-stimulus) amplitude and latency to target and novel stimuli, respectively. A total 166 participated in the ERP data collection.

Child Externalizing Behaviors at T2 and T1

Three Chinese versions of the Child Behavior Checklist for Ages 6–18 years (CBCL/6–18, 115 items), Teacher Report Form for Ages 6-18 years (TRF/6–18, 115 items) and Youth Self Report (YSR, 115 items) were used to assess child externalizing behaviors at T2 by mothers, teachers and children on a 3-point scale (2: “often true”, 1: “sometimes”, and 0: “not true”). The items can be summarized into three second-order factors: externalizing, internalizing and other problem (Ivanova et al., 2007). Normalized $T$ scores
(mean=50.00 and standard deviation=10.00) of each second-order factor were obtained from their raw scores and higher $T$ scores indicate more behavior problems. For the purpose of this study, the second-order factor externalizing behaviors of each scale was selected for analysis and the range of the $T$ score for self-, mother- and teacher-report externalizing behaviors were 37.14–103.56, 44.03–91.75 and 44.03–99.85, respectively. Complete data on externalizing behaviour were obtained from 339 children, 333 teachers and 279 mothers, respectively.

These children’s externalizing behavior was also assessed at T1 by their mothers using the CBCL/1.5–5 (99 items) and by their teachers using the TRF (99 items). Similar to the CBCL/6–18 and TRF/6–18, the CBCL/1.5–5, and TRF were rated on the 3-point scale (2: “often true”, 1: “sometimes”, and 0: “not true”) and can be summarized into two second-order factors: externalizing and internalizing behaviors. The raw scores of externalizing behaviors reported by mothers (range in this study: 0–37) and teachers (range in this study: 0–54) were used as potential confounders in the analysis. All the behavior assessment questionnaires were validated among Chinese children (Achenbach & Rescorla, 2001; Ivanova et al., 2007; Liu, Cheng, & Leung, 2011; Liu, Leung, Sun, Li, & Liu, 2012). Complete data on externalizing behavior at T1 were obtained from 350 mothers and 339 teachers.

Other Covariates

In addition to the mother- and teacher-report externalizing behaviors at T1, the other potential covariates include child sex, socioeconomic status (SES), family location (i.e. urban, suburban and rural areas reported by mothers) when the children were recruited
into the cohort and intellectual function (IQ) at T2 measured using the validated Chinese version of the Wechsler intelligence scale for children-revised (WISC-R, Dan, Yu, Vandenberg, Yuemei, & Caihong, 1990; Liu & Lynn, 2015). SES was calculated as the standardized $z$ score of the sum of standardized $z$ scores of mothers’ and father’s education years and monthly wage as described in Straus (2004).

**Statistical Analysis**

We obtained complete data on key variables (physical abuse, ERP and externalizing behavior from 159 children. Four children were further excluded because one had an IQ lower than 70 and three had 0 correct responses to targets and novels in the oddball task, and were excluded. Therefore, data from 155 children were used in further analysis.

Sample characteristics of the 155 children were summarized by descriptive statistics, and compared with their counterparts who were not included. Bivariate analyses, including independent $t$ tests, Wilcoxon sum rank test, *Pearson* correlation and *Spearman* correlation were used to examine the bivariate association among physical abuse, externalizing behaviors, behavioral performances and P300. The P300 variables that showed bivariate relationships with physical abuse or externalizing behaviors with $p$ values less than 0.25 were submitted to the path analysis as potential mediators (Bursac et al., 2008).

Path analysis using structural equation modeling (SEM) was constructed to analyze the mediating effect of P300 based on the model shown Figure 3.1. The maternal and paternal physical abuse served as the initial exogenous variables with paths to externalizing behaviors and the P300 variable identified from the above process
controlling for the covariates. The full information maximum likelihood method was used to address the missing data with the mother- and teacher-report externalizing at T1.

Because a mediation model is saturated, the commonly used goodness of fit indices, such as root square error of approximation (RMSEA), comparative fit index (CFI) and Tucker-Lewis Index (TFI) cannot be applied. Instead, as recommended by Kenny (2016), Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were used to evaluate the mediation model by comparing with the model without the direct path, with the model without path from predictor to mediator, and with the model without path from mediator to the outcome, respectively. The model with the smallest AIC or BIC was selected. Bootstrapping method with 500 replications was used to estimate the bias corrected 95% confidence interval for the indirect, direct and total effects. The significance level was set at $\alpha=0.05$. Analyses were performed using STATA 13.0 for Windows (College Station, TX).

Results

Sample Characteristics

Out of the 414 children, 155 with complete data of child physical abuse and externalizing behavior at T2 variables were included in the analysis. Comparisons of these children and the remaining children who were not included in this study demonstrated no significant differences in age, sex, socioeconomic status, family location, externalizing behaviors at T1 and T2, and maternal and paternal physical abuse experiences. Table 3.1 displays the sample characteristics and the comparison results.
Bivariate Associations of Physical Abuse with Behavioral Performances on the Oddball Task, P300 and Externalizing Behaviors

Children with maternal physical abuse experiences displayed significantly increased novelty P300 amplitude (\(t=2.35, p=0.02\)) and more self- and mother-report externalizing behaviors (\(t=3.07\) and 2.53, respectively, \(p\) values< 0.05) when compared with their non-maternal-abused counterparts. Similarly, children with paternal physical abuse showed significantly more self-report and teacher-report externalizing behaviors than their non-paternal-abused counterparts (\(t=2.15\) and 2.12, respectively, \(p\) values <0.05). Neither maternal nor paternal physical abuse showed significant associations with the behavioral performances on the oddball task. See Table 3.2.

Pearson Correlation between Externalizing Behaviors and P300

Novelty P300 amplitude was significantly associated with both self- and mother-report externalizing behaviors (\(r=0.25\) and 0.17, respectively, \(p\) values < 0.05). Therefore, novelty P300 amplitude was submitted to the path analysis as a mediator. The \(p\) values of the associations between all other P300 variables and physical abuse and externalizing behaviors were above 0.25 level, as such they were not submitted to the path analysis. See Table 3.3.

Path Analysis Results

A mediation model as shown in Figure 3.1 was initially constructed using maternal and paternal physical abuse and the covariates as exogenous variables, novelty P300 amplitude as the mediator and the externalizing behaviors reported by three sources as
the outcomes. Based on the results, several modifications were made to keep the model parsimonious. First, mother-report externalizing behaviors at age 6 years old was removed from the covariate list because it was not significantly related to the mediator and externalizing behaviors, and removing it improved the model fit (AIC decreased from 8180.95 to 7290.70, and BIC decreased from 8497.47 to 7564.60). Next, teacher- and mother-report externalizing behaviors at T2 were removed consecutively from the model because they did not show significant associations with maternal and paternal physical abuse and novelty P300 amplitude (AIC decreased to 5157.96 and BIC decreased to 5355.78 after removal). Lastly, physical abuse by father was removed because it was not related to the mediator and self-report externalizing behaviors (AIC decreased to 5030.68 and BIC decreased to 5195.02).

The final model and path coefficients were displayed in Figure 3.2. The indirect, direct and total effects with bias-corrected 95% confidence interval using the bootstrapping method were 0.93 (0.22–2.49), 4.10 (0.05–9.78), and 5.03 (0.96–10.19), respectively. Next, the final model was compared with itself without direct path, as well as without the path from maternal abuse to novelty P300 amplitude, and without the path from novelty P300 amplitude to self-report externalizing behaviors, respectively. The results showed that the final model itself has the smallest AIC and BIC (Table 3.4). Taken together, novelty P300 amplitude mediated the relationship between maternal physical abuse and self-report externalizing behaviors. The indirect effect accounts for 18.5% of the total effect between maternal physical abuse and self-report externalizing behaviors.
Discussion

This study is one of the first to examine the possible mediation of P300 underlying the relationship between physical abuse and child externalizing behaviors differentiating maternal and paternal abusers and using externalizing behaviors collected from multiple informants in Chinese children. The present study reveals that children who were physically abused by their mothers displayed increased novelty P300 amplitude and the novelty P300 mediated the relationship between maternal physical abuse and self-report externalizing behaviors among school-aged Chinese children, adjusting for child sex, socioeconomic status, family location, IQ and externalizing behaviors in preschool. This study did not find significant mediating effect of novelty P300 amplitude in the relationship between maternal physical abuse and externalizing behaviors reported by mothers or teachers, significant associations of paternal abuse with externalizing behaviors or any P300 variables, and significant associations between externalizing behaviors and novelty P300 latency and target P300 amplitude and latency.

Physical Abuse, Externalizing Behaviors and Novelty P300 Amplitude

Physical abuse and increased novelty P300 amplitude

This study found increased novelty P300 amplitude among children with maternal abuse experience. This is consistent with the findings that abused children showed hypervigilant feature to negative visual or vocal stimuli (McCory et al., 2010; McCrory et al., 2011, 2012; Pollak, Klorman, Thatcher, & Cicchetti, 2001; Pollak & Tolley-Schell, 2003; Shackman & Pollak, 2014; Shackman et al., 2007). P300 response to novel stimuli (i.e.,
stimuli with low probability, task-irrelevant but contextual salience) is commonly regarded as reflecting a bottom-up process of attention orienting to prepare organism for deviant events in the environment at the brain-electrical level (Debener, Kranczioch, Herrmann, & Engel, 2002; Polich, 2007). The common feature of increased P300 amplitude to novel auditory stimuli and negative visual/vocal stimuli suggests that physically abused children might be more sensitive to the unexpected and infrequent environmental cues and tend to allocate more attentional resources towards these cues. This feature may reflect an adaptive mechanism for abused children to be capable of detecting, and hence reacting to potential social threats in the environment efficiently (McCrory et al., 2012).

**Novelty P300 and externalizing behaviors**

The path analysis showed that increased novelty P300 amplitude was further associated with more externalizing behaviors. It may be because the enhanced allocation of attention to novel stimuli associated with physical abuse is at the cost of other neurocognitive processes (McCrory et al., 2012; Shackman et al., 2007) that are important for producing or regulating normal behaviors. Therefore, physically abused children are more prone to behavior problems. According to the social information processing theory, it is also possible that the misinterpretation of novel information as alerting or threatening may trigger child externalizing behaviors (Crick & Dodge, 1994). Moreover, it can also be explained by the stimulation-seeking hypothesis of externalizing behaviors that physically abused children who showed more interest in the non-repeated novel stimuli
are more likely to exhibit externalizing behaviors (Raine & Venables, 1987, 1988; Roberti, 2004).

It is worth noting that the empirical findings on the relationship between novelty P300 and behaviors are still mixed. Gao et al. (2011) did not find significant difference of novelty P300 among psychopaths who were not convicted of crimes, psychopaths who were convicted of crimes and healthy controls. However, these researchers found, compared with the psychopaths convicted of crimes, prolonged P300 latency and increased P300 amplitude to nontarget stimuli in psychopaths without crimes, which may indicate enhanced capacity in retaining information and increased inhibitory capability that enable psychopaths to succeed in escaping crimes. In contrast, other researchers found reduced novelty P300 amplitude among criminal psychopaths (Venables & Patrick, 2014), offenders (Brazil et al., 2012), or males convicted of spousal/partner abuse (Stanford, Conklin, Helfritz, & Kockler, 2007) in comparison to the healthy controls. The inconsistency may be due to variations in study population characteristics, task paradigms to elicit P300, and different EEG recording sites. In particular, the participants in these studies were predominantly male adults with different characteristics. Very few studies focused on healthy child and adolescent population with mild forms of externalizing behaviors. Therefore, more studies are warranted to investigate the psychophysiological etiology of externalizing behaviors in childhood.

Mediating effect of novelty P300

The mediating effect of novelty P300 amplitude in this study is consistent with the study findings that attention problems mediated the relationship between physical abuse and
aggression in children and adolescents (Garrido, Taussig, Culhane, & Raviv, 2011), and that attention bias towards mothers’ angry faces or voices indicated by enhanced P300 amplitude mediated the association of physical abuse and anxiety (Shackman et al., 2007). In contrast, Shackman and Pollak (2014) found no significant mediating effect of P300 in the relationship between physical abuse and aggressive behavior. Shackman and Pollak (2014) argued that attention allocation only relates to the initial stage of the complicated information processing that underlies aggression, which may account for a very small portion of the relationship between physical abuse and aggressive behavior. The significant mediation in this study may suggest that attention bias may be a shared common feature of the generic externalizing behaviors.

**Target P300 and Externalizing Behaviors**

This study did not find a significant relationship between target P300 and externalizing behaviors. Target P300 is regarded as a top-down process subsequent to attentional resource activations when memory updating and storage is facilitated in the temporal-parietal areas (Polich, 2007). Reduced target P300 is regarded as impaired neurocognitive functioning especially in regards to working memory functioning (Gao & Raine, 2009). Previous research consistently reported reduced target P300 amplitude among individuals with generic antisocial behavior (for a meta-analysis, see Gao & Raine, 2009). Euser et al. (2012) even suggested that reduced P300 amplitude to target stimuli is a neurobiological disease marker for substance abuse disorders. Given that target P300 is dominant in the hippocampal temporal/parietal junction area that is related to memory updating (Polich, 2007), one possible reason for the non-significant finding could be that
the grand average of target P300 across all 12 electrodes on the scalp may reduce the sensitivity to detect its potential relationship with externalizing behaviors. It is also possible that the oddball task used in this study is not complex enough to reveal potential working memory deficiency.

Maternal vs. Paternal Physical Abuse

The present study did not find a significant association of paternal physical abuse with P300 and externalizing behaviors in the path analysis, which is consistent with the previous findings. For example, Gao et al. (2010) reported that paternal care was not significantly associated with psychopathy after controlling for maternal care. Likewise, a meta-analysis by Kawabata et al. (2011) found that maternal parenting stress was associated with child relational regression, whereas paternal parenting stress was not. In addition, paternal and maternal may link to externalizing behaviors through different neurocognitive pathways (Xing et al., 2016). It is possible that the neurocognitive pathway underlying the association of paternal abuse and externalizing behaviors may be not captured by the P300.

Limitations

Study limitations should be considered in explaining the findings. First, the P300 used in this study is an average value of P300 recorded by all 12 electrodes across the scalp. P300 elicited by target stimuli of a standard oddball task is peaked at parietal sites and P300 elicited by novel stimuli is usually maximally recorded at frontal sites (Hajcak, MacNamara, & Olvet, 2010; Polich, 2007). The present study used the average values of
P300 amplitude and latency across scalp to provide initial evidence for the mediating effect of P300 in the relationship between physical abuse and externalizing behaviors among Chinese children. Although two meta-analytic studies (Euser et al., 2012; Gao & Raine, 2009) did not find significant heterogeneity across electrode sites in terms of the relationships between P300 and externalizing behaviors, more studies are needed to investigate the mediating effect of P300 recorded at a specific site, especially the frontal, prefrontal and parietal sites.

Further studies on whether novelty P300 amplitude can be a biomarker for the etiology or treatment effect of externalizing behaviors are also needed to determine the causal relationship between novelty P300 amplitude and externalizing behaviors related to maternal physical abuse. Also, despite the shared commonalities, different subtypes of externalizing behaviors have their own characteristics (Krueger & South, 2009; Liu, 2004). Researchers can conduct more studies to investigate the relationship between specific subtypes of externalizing behaviors and child abuse and P300.

A considerable proportion of children of the original sub-cohort did not participate in the psychophysiological data collection. Comparisons of the sociodemographic characteristics between the retained children and excluded children due to missing data or drop-out from the parent study did not show significant differences. Therefore, the present sample of children is regarded as a representative sample in terms of the measured sociodemographic information and physical abuse and behavior profiles. However, these children may differ in unobserved characteristics. We
recommend researchers to conduct further studies to replicate the findings in representative samples.

Lastly, although the sample size of the present study is considered as large in the ERP literature, the sample size may still be too small to detect direct and indirect effects indicated by the wide confidence interval of the total and direct effects. Kenny & Judd (2014) found that in a mediation model, total and indirect effects usually have lower power to be detected in comparison to the mediating effect. Therefore, studies using larger sample size may be helpful to obtain more precise estimates of total and direct effects between physical abuse and externalizing behaviors.

Conclusion

Our findings support that physically abused children showed increased P300 amplitude to novel stimuli, which further linked to more externalizing behaviors. The findings contribute to the knowledge of the psychophysiological pathway underpinning the relationship between physical abuse and externalizing behaviors. This study also indicates that the attention bias to novel/negative stimuli in the environment, which could be targeted to prevent or treat childhood externalizing behaviors that were subsequent to physical abuse.
References


Table 3.1. Sociodemographic characteristics of the present sample and comparisons with the children not included in the present study

<table>
<thead>
<tr>
<th></th>
<th>Children included ( (n=155) )</th>
<th>Children excluded ( (n=259) )</th>
<th>( t/\chi^2 )</th>
<th>( p ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age ( (n=155, n_e=257) )</td>
<td>11.28±0.57</td>
<td>11.32 ±0.54</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td>0.01</td>
<td>0.98</td>
</tr>
<tr>
<td>Girls</td>
<td>69 (44.5)</td>
<td>115 (44.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>86 (55.5)</td>
<td>144 (55.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family location</td>
<td></td>
<td></td>
<td>0.20</td>
<td>0.91</td>
</tr>
<tr>
<td>Urban</td>
<td>66 (42.6)</td>
<td>113 (43.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suburban</td>
<td>65 (41.9)</td>
<td>110 (42.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>24 (15.4)</td>
<td>36 (13.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES ( (n=133, n_e=140) )</td>
<td>0.19±0.99</td>
<td>0.22±0.98</td>
<td>0.24</td>
<td>0.81</td>
</tr>
<tr>
<td>IQ ( (n=113, n_e=91) )</td>
<td>105.65±11.39</td>
<td>103.40±13.09</td>
<td>1.31</td>
<td>0.19</td>
</tr>
<tr>
<td>S_EXTER at T2 ( (n=155, n_e=184) )</td>
<td>52.52±11.43</td>
<td>51.18±9.67</td>
<td>1.11</td>
<td>0.27</td>
</tr>
<tr>
<td>M_EXTER at T2 ( (n=136, n_e=143) )</td>
<td>51.67±12.51</td>
<td>49.50±9.96</td>
<td>1.54</td>
<td>0.13</td>
</tr>
<tr>
<td>T_EXTER at T2 ( (n=148, n_e=185) )</td>
<td>50.06±11.45</td>
<td>49.61±10.85</td>
<td>0.35</td>
<td>0.72</td>
</tr>
<tr>
<td>M_EXTER at T1 ( (n=132, n_e=218) )</td>
<td>13.23±6.74</td>
<td>13.47±6.96</td>
<td>0.31</td>
<td>0.76</td>
</tr>
<tr>
<td>T_EXTER at T1 ( (n=129, n_e=210) )</td>
<td>8.58±8.61</td>
<td>9.25±9.25</td>
<td>0.66</td>
<td>0.51</td>
</tr>
<tr>
<td>Maternal physical abuse</td>
<td></td>
<td></td>
<td>2.52</td>
<td>0.11</td>
</tr>
<tr>
<td>Yes</td>
<td>51 (32.9)</td>
<td>37 (24.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>104 (67.10)</td>
<td>113 (75.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paternal physical abuse</td>
<td></td>
<td></td>
<td>1.24</td>
<td>0.27</td>
</tr>
<tr>
<td>Yes</td>
<td>54 (37.8)</td>
<td>47 (29.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>101 (65.2)</td>
<td>115 (71.0)</td>
<td></td>
<td></td>
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</tbody>
</table>

Notes. SES, socioeconomic status; IQ, intellectual quotient; S_EXTER, child self-report externalizing behaviors; M_EXTER, mother-report externalizing behaviors; T_EXTER, teacher-report externalizing behaviors. Family location were self-identified. T2 indicates data were collected in 2013 when children were in grade 6 elementary school and T1 indicates that data were collected in 2007 when children were in K3 preschool. \( n_i \), number of children with available information included in this study; \( n_e \), number of children with available information but not included in this study.
Table 3.2. Comparisons of behavior problems, behavior performance on Oddball task and P300 between physically abused children and their non-abused counterparts

<table>
<thead>
<tr>
<th></th>
<th>Maternal Physical Abuse</th>
<th>Paternal Physical Abuse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No (M±SD)</td>
<td>Yes (M±SD)</td>
</tr>
<tr>
<td>S_EXTER at T2</td>
<td>50.60±9.24</td>
<td>56.43±14.24</td>
</tr>
<tr>
<td>M_EXTER at T2</td>
<td>49.80±9.35</td>
<td>55.45±16.71</td>
</tr>
<tr>
<td>T_EXTER at T2</td>
<td>49.87±11.8</td>
<td>50.44±10.82</td>
</tr>
<tr>
<td>M_EXTER at T1</td>
<td>12.84±6.91</td>
<td>14.12±6.34</td>
</tr>
<tr>
<td>T_EXTER at T1</td>
<td>7.98±8.34</td>
<td>9.93±9.16</td>
</tr>
<tr>
<td>Mean reaction time</td>
<td>504.07±97.5</td>
<td>482.64±78.09</td>
</tr>
<tr>
<td>Correct response to target</td>
<td>31.38±4.22 (33)</td>
<td>30.58±5.35 (32)</td>
</tr>
<tr>
<td>Errors to novels</td>
<td>5.63±7.44 (3)</td>
<td>5.54±6.95 (3)</td>
</tr>
<tr>
<td>Errors to non-targets</td>
<td>1.59±2.05 (1)</td>
<td>1.94±1.97 (1)</td>
</tr>
<tr>
<td>Novelty P300 amplitude (μV)</td>
<td>9.63±4.47</td>
<td>11.40±4.30</td>
</tr>
<tr>
<td>Novelty P300 latency (ms)</td>
<td>325.18±172.76</td>
<td>307.29±183.87</td>
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<tr>
<td>Target P300 amplitude (μV)</td>
<td>10.98±7.13</td>
<td>11.08±9.36</td>
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<tr>
<td>Target P300 latency (ms)</td>
<td>329.85±174.18</td>
<td>336.47±188.84</td>
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</tbody>
</table>

Notes. S_EXTER, child self-report externalizing behaviors; M_EXTER, mother-report externalizing behaviors; T_EXTER, teacher-report externalizing behaviors. T2 indicates data were collected in 2013 and T1 indicates that data were collected in 2007. The parenthetical numbers in the 2\textsuperscript{nd}, 3\textsuperscript{rd}, 5\textsuperscript{th} and 6\textsuperscript{th} columns refer to the medians of the variables among corresponding subgroup of children. Superscript w, Wilcoxon rank-sum test.
Table 3.3. Pearson correlations between ERP and behavior problem

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 S_EXTER at T2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 M_EXTER at T2</td>
<td>0.575***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 T_EXTER at T2</td>
<td>0.247**</td>
<td>0.278**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Novelty P300 amplitude (μV)</td>
<td>0.255**</td>
<td>0.174*</td>
<td>0.032</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Novelty P300 latency (ms)</td>
<td>-0.039</td>
<td>-0.088</td>
<td>0.019</td>
<td>-0.124</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>6 Target P300 amplitude (μV)</td>
<td>0.028</td>
<td>0.054</td>
<td>0.021</td>
<td>0.250**</td>
<td>0.013</td>
<td>1</td>
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<tr>
<td>7 Target P300 latency (ms)</td>
<td>0.002</td>
<td>0.046</td>
<td>0.082</td>
<td>0.008</td>
<td>0.053</td>
<td>0.044</td>
</tr>
</tbody>
</table>

Notes. S_EXTER, child self-report externalizing behaviors; M_EXTER, mother-report externalizing behaviors; T_EXTER, teacher-report externalizing behaviors. T2 indicates data were collected in 2013. *, p<0.05; **, p<0.01; ***, p<0.001
Table 3.4. Comparisons of the AIC and BIC of different models

<table>
<thead>
<tr>
<th>Model Description</th>
<th>AIC</th>
<th>BIC</th>
</tr>
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<tbody>
<tr>
<td>Final mediation model</td>
<td>5030.68</td>
<td>5195.02</td>
</tr>
<tr>
<td>Final mediation model without the direct path</td>
<td>5033.36</td>
<td>5195.67</td>
</tr>
<tr>
<td>Final mediation model without the path from maternal physical abuse to novelty P300 amplitude</td>
<td>5034.04</td>
<td>5195.34</td>
</tr>
<tr>
<td>Final mediation model without the path from novelty P300 amplitude to self-report externalizing behaviors</td>
<td>5035.58</td>
<td>5196.88</td>
</tr>
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</table>

*Notes. AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion. The final model refers to the model displayed in Figure 3.2.*
Figure 3.1. The full mediation model.

The model illustrates the relationship between maternal and paternal physical abuse and externalizing behaviors reported by children themselves (S_EXTER), mothers (M_EXTER), and teachers (T_EXTER), and the mediating role of P300. The variable P300 refers to any of the following variables: novelty P300 amplitude, novelty P300 latency, target P300 amplitude and target P300 latency. All the variables in the figure were measured at T2. The model was adjusted child sex, socioeconomic status, family location, IQ, and externalizing behaviors in preschool at T1.
Figure 3.2. The final mediation model.

The model illustrates that novelty P300 amplitude mediated the relationship between maternal physical abuse and self-report externalizing behaviors. *, \( p < 0.05 \); ** \( p < 0.01 \).
CHAPTER 4: COGNITIVE AND BEHAVIORAL RISK FACTORS FOR CHILD PHYSICAL ABUSE AMONG CHINESE CHILDREN:
A MULTIPLE-INFORMANT STUDY

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5 This chapter is modified from an open access publication in Child and Adolescent Psychiatric and Mental Health. The publication is the author’s original work and the copyright is Author(s) ©. Approval was obtained from both authors.
Abstract

**Background:** It has been well established that child physical abuse is a risk factor for cognitive deficits and behavior problems. However, the possible link between cognitive deficits and behavior problems placing children at high risk of physical abuse has been overlooked. Using a prospective design, the present study aims to examine whether previously measured cognition measured by intelligence quotient (IQ), including performance IQ (PIQ) and verbal IQ (VIQ), and behavior problems reported by multiple informants (i.e. mothers, teachers, and children) predict later child physical abuse (which may include minor and severe forms of abuse inflicted separately by mothers and fathers) in Chinese children.

**Methods:** A school-based survey was conducted to collect data from 265 Chinese children (52.8% boys, mean age 13.71±0.60 years) in the Wave II of China Jintan Cohort study. When they were in the last year of elementary school, children completed the Chinese version of the Wechsler Intelligence Scale for Children-Revised that measured VIQ and PIQ during 2010–2012 when their behaviors were self-assessed. Mothers and teachers of these children used the Chinese versions of the Youth Self Report, the Child Behavior Checklist, and the Teacher Report Form, respectively, to assess the children’s behaviors. These children reported minor and severe physical abuse experiences in the previous 12 months from mothers and fathers separately using the Chinese version of parent–child Conflict Tactics Scale in 2013 when children were in grades 7 and 8 of middle school.
Results: The present study found that after controlling for the sociodemographic, cognitive and/or behavior variables, high scores of child externalizing behaviors rated by their mothers or teachers were associated with increased risks of experiencing maternal and paternal severe physical abuse, while a high score of self-report externalizing behaviors was associated with a decreased risk of paternal severe physical abuse. A high score of mother-report internalizing behaviors was associated with a decreased risk of maternal severe physical abuse. VIQ was associated with maternal minor physical abuse with small effect size. PIQ was not associated with any forms of physical abuse after adjusting for child behavior and sociodemographic variables.

Conclusions: In this community sample of Chinese children, externalizing behaviors perceived by mothers and teachers is linked to children being at risk for physical abuse, while internalizing behaviors perceived by mothers is associated with a decreased risk of maternal physical abuse. Findings suggest that educating parents and teachers to appropriately perceive children’s externalizing behaviors may help prevent the occurrence of physical abuse.

Keywords: child physical abuse, behavior, cognition, China
**List of Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviations</th>
<th>Full name</th>
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<tbody>
<tr>
<td>IQ</td>
<td>Intelligence Quotient</td>
</tr>
<tr>
<td>VIQ</td>
<td>Verbal Intelligence Quotient</td>
</tr>
<tr>
<td>PIQ</td>
<td>Performance Intelligence Quotient</td>
</tr>
<tr>
<td>CTSPC</td>
<td>Parent–child Conflict Tactics Scale</td>
</tr>
<tr>
<td>YSR</td>
<td>Youth Self Report</td>
</tr>
<tr>
<td>CBCL</td>
<td>Child Behavior Checklist</td>
</tr>
<tr>
<td>TRF</td>
<td>Teacher Report Form</td>
</tr>
<tr>
<td>WISC-R</td>
<td>Wechsler Intelligence Scale for Children-Revised</td>
</tr>
<tr>
<td>SES</td>
<td>Socioeconomic status</td>
</tr>
<tr>
<td>GLM</td>
<td>Generalized Linear Model</td>
</tr>
<tr>
<td>OR</td>
<td>Odds Ratio</td>
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<tr>
<td>RR</td>
<td>Risk Ratio</td>
</tr>
<tr>
<td>CI</td>
<td>Confidence Interval</td>
</tr>
<tr>
<td>S_EXTER</td>
<td>Self-report Externalizing Behaviors</td>
</tr>
<tr>
<td>M_EXTER</td>
<td>Mother-report Externalizing Behaviors</td>
</tr>
<tr>
<td>T_EXTER</td>
<td>Teacher-report Externalizing Behaviors</td>
</tr>
<tr>
<td>S_INTER</td>
<td>Self-report Internalizing Behaviors</td>
</tr>
<tr>
<td>M_INTER</td>
<td>Mother-report Internalizing Behaviors</td>
</tr>
<tr>
<td>T_INTER</td>
<td>Teacher-report Internalizing Behaviors</td>
</tr>
</tbody>
</table>


**Background**

Child physical abuse has gained increasing attention in China, especially after the recent enactment of the first national law prohibiting domestic violence (*The Law against Domestic Violence of People’s Republic of China*) in March 2016. Despite being prohibited by the law, child physical abuse is still highly prevalent among Chinese children. A recent meta-analysis of 47 Chinese studies reported that about half of Chinese children have experienced minor physical abuse and about 1 in 5 children have experienced severe physical abuse [1], which is higher than the estimated global prevalence of physical abuse and the estimated prevalence in Asian countries [2]. Child physical abuse shows associations with increased risks of physical, behavioral, cognitive, and psychological problems during childhood, and such effects can last into adulthood [3,4]. The adverse consequences related to child maltreatment, in turn, cause high societal costs in China [3,4], as they do in other developed countries [5]. However, unlike in developed countries that have launched various prevention programs to prevent child maltreatment [6,7], there are very few prevention and intervention programs to protect children against abuse in China. There is a need of research on modifiable risk factors of child maltreatment to shed lights on developing effective prevention programs in China.

Parent–child interaction is a reciprocal process. While the mainstream research interprets parental abusive behavior as a risk factor for behavior problems (i.e. a parent effect), it is possible that children with cognitive deficits and behavior problems may elicit parental abusive behavior (i.e. a child effect). The latter line of explanation is supported by the limited evidence from both cross-sectional and longitudinal studies that found
bidirectional relationships between child maltreatment and behavioral outcomes: on one hand, abused children had more behavior problems in later childhood after controlling for previous behavior problems, and, on the other hand, children with behavior problems were more likely to experience coercive parenting or child maltreatment after controlling for the previous abuse experiences [8-11]. Similarly, a meta-analysis study also revealed that the “parent perceives child as problem” viewpoint was a risk factor for child physical abuse [12]. In addition, researchers have also found a significant child effect in terms of intelligence. Children with low intelligence quotient (IQ) were at high risk of childhood abuse or exposure to trauma [13-15].

The child effect that child behavior problems may elicit parental practice of abuse may be particularly salient in China due to traditional Chinese culture. Chinese culture regards harsh child discipline as necessary to increase children’s morality and obedience to social harmony when they misbehave [16-18]. Leung et al. conducted a large-scale study in southern China and found the most common reason for abuse was “disobedience to parents,” which is usually regarded as misbehavior by Chinese parents [19]. Consistently, a qualitative study found that Chinese parents hold the view that they only practice physical discipline when their children misbehave, and the purpose of the physical discipline is to correct child’s behavior for the child’s good [18]. Even the survivors of child maltreatment agreed that they were physically abused because they did something wrong [20]. However, the cognitive and behavioral risk factors for child maltreatment in China have been understudied.
The present literature is limited because the researchers collected child behavior data from only one informant source, usually either mothers or children, which may not comprehensively capture the complexity of child behavior. Research shows that there is a situational effect of child behavior: parents and teachers may hold different perceptions of child behavior, which is also different from the child’s own perception of his/her behavior [21]. However, it remains unknown whether child behavior perceived by different informants is associated with child physical abuse in a different or similar fashion.

Another limitation in the literature is that most studies assess child maltreatment as practiced by both of the parents, or only the mother, yet it fails to distinguish child maltreatment as practiced separately by both the mother and the father. Studies have found gender differences in parenting styles, with mothers demonstrating more authoritative (i.e., emotionally supportive and responsive) parenting styles and fathers exhibiting more authoritarian (i.e., less supportive and high-controlling) parenting styles [22,23]. In addition, researchers have reported that maternal and paternal parenting has different effects on children’s behavior in China [24,25]. Therefore, it is necessary to consider maternal and paternal abusive behaviors simultaneously, yet separately.

In summary, this study aims to examine the associations of previously measured IQ and behavior problems (reported by mothers, teachers, and children) with later child physical abuse by mothers and fathers, respectively.

Methods
Procedures and Participants

The present study used secondary data collected from the Wave II of the Jintan Child Cohort Study, which is an ongoing prospective longitudinal study. The cohort study recruited 1385 children aged 3-5 years old from upper grade (i.e. mean age about 5 years old), middle grade (i.e. mean age about 4 years old), and bottom grade (i.e. mean age about 3 years old) in preschools in Jintan, China in 2004-2005, which was a representative sample of children in the city in terms of gender, age, and residential locations. The cohort study design was described elsewhere [26-28].

The children from upper grade, middle grade, and bottom grade were followed up with during the Wave II to assess behavior problems (reported by children, mothers, and teachers) and IQ in 2010–2011, 2011–2012, and 2013 when they were in the last year of elementary school, respectively. These children were also invited to participate in a child maltreatment questionnaire survey in 2013 when children were 6th (elementary school), 7th (middle school) and 8th graders (middle school), respectively. In order to maintain temporal order to test the association of IQ and behavior problems in earlier life and later child maltreatment, we included the 7th and 8th graders whose behavior problems and IQ were assessed in 2010–2011 and 2010–2012, and child physical abuse was assessed in 2013. We obtained complete data from 265 children (47.2% boys). The temporal design of the parent cohort study and the present study is shown in Figure 4.1. Compared with those who did not have complete data, these children did not show significant differences in age, verbal IQ (VIQ), performance IQ (PIQ), or externalizing and internalizing behaviors (regardless of the reporters), or minor or severe physical
abuse (regardless of the abusers). There were slightly more girls, more children from better socioeconomic background, and fewer children from the rural areas in the retained sample (Supplemental Table S4.1).

The China Jintan Child Cohort Study obtained written informed consent from both mothers and teachers and verbal assent from children during the Wave II of data collection. Two trained research assistants distributed and collected the questionnaires, explained the objectives and confidentiality of the study and the principle of voluntary participation and participations’ right of withdrawing the study at any time point, and answered any of the respondents’ questions. All questionnaire surveys for the children took place in classrooms during school hours. Children completed the IQ test at Jintan Hospital and, in the meantime, parents rated their children’s behavior in the waiting rooms. Teachers rated child behavior in their offices after understanding the study. The cohort study obtained approval from the Institutional Review Board of the University of Pennsylvania and the Ethical Committee for Research at Jintan Hospital, China.

**Measures**

*Child physical abuse:* Children’s physical abuse experiences were assessed by the Parent–child Conflict Tactics Scale-Child version (CTSPC) [29] in 2013, which consists of 27 items covering four categories of parental behaviors: (1) nonviolent disciplinary behaviors (4 items), (2) psychological aggression (5 items), (3) physical abuse, including minor form (6 items, including spanking with bare hand, hitting bottom with objects,
slapping on hand or arm or leg, slapping on face or head or ears, pinching, shaking or pushing) and severe form (7 items, including hitting other part of body besides bottom with objects, throwing or knocking down, hitting with a fist or kicking hard, beating up, choking, burning, threatening with a weapon), and (4) neglect (5 items). Children were asked to provide information on whether their mothers and fathers separately displayed these behaviors in the preceding year (0=“No”, or 1=“Yes”). For the purpose of the study, we focused on the minor and severe forms of child physical abuse. Non-abused children were those with zeros on all items in the corresponding subscales. Otherwise, they were labeled as minor or severe physical abuse survivors. The available Chinese version of the CTSPC showed satisfactory to good reliability (0.58–0.87 [30]). The subscales of minor and severe physical abuse showed good reliability for maternal vs. paternal behaviors (minor physical abuse: 0.73 vs. 0.77; severe physical abuse: 0.69 vs. 0.65) in the study.

Child externalizing and internalizing behaviors: Three questionnaires from the Achenbach System of Empirically Based Assessment (ASEBA) were used to assess child behavior. Parents and teachers completed the validated Chinese versions of the Child Behavior Checklist for Ages 6–18 (CBCL/6–18) and the Teacher Report Form (TRF/6–18), respectively. Children self-report their behaviors using the validated Chinese version of Youth Self-Report (YSR) [31,32]. The CBCL and TRF consist of 115 items each, while the YSR consists of 112 items. The questionnaire items were rated on a 3-point scale (0=not true, 1=sometimes true, and 2=often true), from which normalized $T$ scores (the ratio of behavior score’s deviation from the population mean to its standard
deviation) were calculated. A higher $T$ score indicates more behavior problems. The researchers classified all items into three factors: externalizing behaviors, internalizing behaviors, and other problems. In the present study, the factors of externalizing behaviors (score range in the study: 37.13-87.74) and internalizing behaviors (score range in the study: 35.28-110.50) were used in the following analyses.

**Cognition:** The researchers assessed children’s cognition using the Chinese version of the Wechsler Intelligence Scale for Children-Revised (WISC-R), which measured children’s PIQ and VIQ and showed good reliability and validity among Chinese children ages 6–17 years old [33]. Details of the test were described elsewhere [34,35].

**Sociodemographic co-variables:** Children completed a self-administered General Information Questionnaire to provide information about their gender, age when child maltreatment was assessed, grade when their abuse experience was assessed, fathers’ and mothers’ number of years of education, and fathers’ and mothers’ monthly wage. Their mothers were asked the current family location (i.e. urban, suburban, or rural) when the children were recruited in the cohort study. We generated an indicator of socioeconomic status (SES) according to the procedure described in [36]. It is the standardized $z$ score of the sum of $z$-scores of children’s father’s and mothers’ number of years of education and monthly wage.

**Data Analysis**

We first ran descriptive analyses for all variables. We described the prevalence of child physical abuse by mothers and fathers, respectively, and compared the
intelligence and behavioral characteristics of children with a specific type of abuse to those without it. We then ran variance inflated factor (VIF) analysis to determine the multicollinearity of the independent variables. The result showed that VIF of the six behavior variables ranged from 2.07 to 2.32. Therefore, multicollinearity of behavioral variables was not a severe concern. Age and grade were highly correlated and, thus, only grade was controlled in multivariate analyses. In order to illustrate meaningful odds ratios, we rescaled VIQ, PIQ, and behavior variables by dividing each of them by 10. Therefore, the OR and 95% confidence intervals indicate a change in the risk of being maltreated with a 10-point increase in VIQ, PIQ, or behavior scores. Using the rescaled IQ and behavior scores as independent variables, we constructed four generalized linear models with binomial family and logit link function to test the association of IQ and behavior problems with the risk of child physical abuse 1 or 2 years later, controlling for the covariates. Minor or severe physical abuse by mothers and fathers were treated as dependent variables in the four models, respectively. Next, we constructed GLMs with binomial family and log link to obtain the risk ratio (RR) for the significant cognitive and behavioral factors associated with physical abuse to estimate the effect sizes of their associations with physical abuse. In order to get convergent GLMs with log link, one case with the highest predicted value obtained from the GLMs with logit link was removed for each GLM model with log link. We set the significance level at $\alpha = 0.05/4 = 0.125$ using the Bonferroni correction of four outcomes, and regarded a $p$ value less than 0.05 but higher than 0.0125 as marginally significant or a trend of significance. We
performed all the analyses using STATA 13.0 for Windows (College Station, TX). The study has sufficient statistical power (Supplemental Material Power Analysis).

Results

Sample characteristics

Among the 265 children, almost half of them experienced minor physical abuse by either their mothers or fathers, and about one-fourth of children experienced severe physical abuse from either their mothers or fathers. Boys were more likely to report physical abuse from their fathers than girls ($\chi^2=6.944, p=0.008$). There is no significant difference between physically maltreated children and their non-maltreated counterparts in terms of age, location, and socioeconomic status. See Table 4.1.

[Insert Table 4.1 to here]

Bivariate associations of child physical abuse with IQ and behavior problems

Children who experienced maternal minor physical abuse in the preceding year had higher scores of externalizing behaviors as rated by their respective mothers (51.31±9.36 vs. 48.35±7.97, $p=0.006, \text{Cohen's } d=0.34$) and themselves (50.92±10.25 vs. 47.85±8.76, $p=0.009, \text{Cohen's } d=0.32$). Children with paternal minor (51.69±9.52 vs. 48.50±8.00, $p=0.003, \text{Cohen's } d=0.37$) or severe physical abuse (52.32±9.69 vs. 49.03±8.37, $p=0.009, \text{Cohen's } d=0.38$) scored higher on externalizing behaviors as rated by their mothers in the past. The effect sizes of these differences are small to medium. Children with an experience of maternal severe physical abuse showed a trend of lower PIQ scores, higher externalizing behaviors scores rated by their teachers, and higher self-report internalizing
behavior scores, while children with paternal severe physical abuse showed a trend of higher scores on teacher-report externalizing behaviors (Table 4.2). However, these results did not reach the significance level at 0.0125.

[Insert Table 4.2 to here]

The adjusted association of IQ and behavior problems with later physical abuse

Table 4.3 illustrates the adjusted associations of child physical abuse with IQ and behavior problems. After adjusting for other variables in the model, the risk of maternal severe physical abuse increased with the increase in the scores of mother- [OR=1.38 (1.09, 1.74), \( p=0.007 \), RR=1.28] or teacher- [OR=1.47 (1.29, 1.69), \( p=0.009 \), RR=1.22] rated externalizing behaviors, while such risk decreased with the increase in the score of mother-report internalizing behaviors [OR=0.77 (0.63, 0.95), \( p=0.011 \), RR=0.79]. Similarly, the risk of paternal severe physical abuse grew with the increase in the scores of mother- [OR=1.47 (1.29, 1.69), \( p<0.001 \), RR=1.31] or teacher-report externalizing behaviors [OR=1.61 (1.44, 1.81), \( p<0.001 \), RR=1.32]. Although a higher score of VIQ was related to increased risk of maternal minor physical abuse [OR=1.06 (1.02, 1.13), \( p=0.006 \), RR=0.04], the effect size was very small. Notably, the ORs change with the increase in behavior scores. For example, with an increase of 20 points in mother-report externalizing behaviors, the odds of maternal severe physical abuse increases from 1.38 to 1.90 (RR increases from 1.28 to 1.64), compared to the odds of not experiencing such abuse. Neither IQ nor behavior problems rated by different informants were significantly associated with the risk of paternal minor physical abuse.
Discussion

To our best knowledge, this study is the first to report the association of cognition measured by VIQ and PIQ, and child behavior rated by different informants with maternal and paternal physical abuse in a cohort sample of children. Although the majority of the participated children showed normal intelligence and behavior scores, within these children, we found that children with high scores of mother- and teacher-report externalizing behaviors were more likely to be severely physically abused by their mothers and fathers, while children with high scores on self-report externalizing behaviors were less likely to be severely physically abused by their fathers. Besides, children with high scores of mother-report internalizing behaviors were less likely to report maternal severe physical abuse in later childhood. PIQ was not associated with any form of child physical abuse. It should be noted that the present study does not suggest that children should be blamed for their abuse by their parents. Instead, findings from the study are expected to help better understand risk factors for child maltreatment, and, therefore, provide evidence for future prevention programs.

*Externalizing behaviors and maternal and paternal physical abuse*

The present study found that mothers’ and teachers’ reports on externalizing behaviors were associated with both maternal and paternal severe physical abuse. This is consistent with the finding from a longitudinal Chinese study that children with high externalizing behaviors experienced more physical abuse 6 months later after controlling for the
previous physical abuse experience [37]. Similarly, Stith et al. conducted a meta-analysis and reported that child externalizing behaviors is a risk factor for child maltreatment [12]. In terms of the effect size of the association between externalizing behaviors and severe physical abuse, the odds ratios are comparable to the estimates from a meta-analysis of 68 Chinese studies treating child maltreatment as a risk factor for behavioral outcomes. This meta-analysis found that the effect sizes of the associations between child maltreatment and behavioral outcomes (e.g. mental health disorders, depression, anxiety, drug use, etc.) range from 1.40–1.98 (Fang et al., 2015). Taken together, the findings indicate that externalizing behaviors perceived by parents or teachers may increase parents’ negative attributions of child behavior that directly increases parenting stress [38] and the tendency of practicing harsh disciplining strategy to correct children’s misbehavior or to reduce their distress.

Interestingly, child self-report externalizing behaviors decreased the risk of paternal severe physical abuse when their mothers’ and teachers’ perceptions of child externalizing behaviors are adjusted. It is possible that Chinese fathers may regard child self-report externalizing behaviors as normal extroversion, and therefore, are less likely to practice severe physical discipline. Very few studies have attempted to examine the association between child behavior and paternal physical abuse, and more studies are needed.

The findings also suggest that there is a discrepancy in the perceptions of externalizing behaviors between children and their parents and teachers. Prior research found that children usually report fewer behavior problems than their parents or other informants
The disparate perspectives of externalizing behaviors may be a source of conflict that triggers parental physical abuse. Hence, it may be effective to prevent child maltreatment by modifying parents’ and teachers’ perceptions of child behavior.

**Internalizing behaviors and maternal severe physical abuse**

We found that higher mother-report internalizing behaviors was associated with less risk of maternal minor or severe physical abuse. Literature from western studies indicates that physically abusive mothers usually rated higher on child internalizing behaviors [12,40], an inconsistent result with the present finding. This inconsistency may indicate that Chinese parents tend not to use physical discipline when they perceive that their children are introverted. Previous research has argued that from the perspective of Chinese parents, the characteristics of internalizing problems may align with desired characteristics in Chinese culture, such as being quiet, introverted and sensitive [37,41]. Therefore, mother-perceived internalizing behaviors relates to less-frequent physical abuse.

**IQ and physical abuse**

Although the positive association between VIQ and maternal minor physical abuse (that is independent of behavior problems and sociodemographic variables) was statistically significant, the effect size is very small. We did not find significant associations of VIQ with other types of physical abuse or significant associations of PIQ with all types of physical abuse. The previous findings of the association between IQ and child maltreatment under the assumption of the child effect are not conclusive. Breslau et al.
conducted a longitudinal study and found that full-scale IQ lower than 115 at the age of 6 increased the risk of exposure to general assaultive violence at age 17, and they explained that children with low IQs might be more likely to interact with disruptive peers and, therefore, be exposed to assaultive violence [14]. In contrast, Brown et al. [42] and Young et al. [13] found that low IQ scores were associated with child neglect but not physical abuse, indicating that different types of child maltreatment may be associated with IQ differently. Further research can be conducted to examine the relationship between IQ and other forms of child maltreatment other than physical abuse in the Chinese context.

The absence of the significant association between IQ and physical abuse could also be because child behavior fully mediates the relationship between IQ and child physical abuse. Prior studies have suggested that children with intellectual disabilities are at higher risk of developing behavior problems that may further make children more prone to physical abuse [43,44]. Future research is warranted to explore the possible mediating role of behavior problems in the relationship between IQ and child maltreatment.

**Study limitations**

The findings should be interpreted cautiously due to study limitations. First, a relatively small proportion of the original cohort children participated in the survey, and there were slightly more girls and less children from rural areas (Supplemental Table S4.1). Therefore, the present study’s generalizability is limited. Despite this, the present study
does exhibit value in offering a new perspective to investigate the relationship between IQ, behavior problems, and child maltreatment.

Second, we did not examine gender differences in the relationships of child physical abuse with IQ and behavior problems concerning low statistical power. Prior studies suggest that there are gender differences in the predictive effect of externalizing and internalizing behaviors on physical abuse among Chinese children. Specifically, compared with Chinese girls, Chinese boys with behavior problems were more likely to experience physical abuse [37,41]. Future studies are needed to explore whether the association between IQ and child maltreatment depends on child gender.

Third, we only collected information on child maltreatment once. The status of child maltreatment prior to the study was not assessed. It is possible that maltreated children in the present sample had also experienced abuse before the study, and such experience may serve as a confounder in the relationship between behavior problems and child physical abuse. Some qualitative studies in the Chinese context that Chinese parents practice harsh discipline towards children because of their misbehavior, disobedience, and poor academic performance [18,20,45]. Longitudinal studies also reported bidirectional relationship between child maltreatment and behavior problems [8,9,11]. It is plausible to regard IQ and child externalizing and internalizing behaviors as potential risk factors for child maltreatment. It is worth noting that the majority of studies regarding child maltreatment as a risk factor for behavior problems failed to control for previous behavior problems. Therefore, we suggest that future research further explore the
reciprocal relationship of child maltreatment with cognition and behavior using sophisticated longitudinal designs.

Lastly, some confounders that were not included in the present study need to be considered for future studies. For example, parental mental health status could be an important confounder that is related to both child maltreatment [46] and child behavior problems [47]. However, very few Chinese researchers have attempted to examine the effect of parental mental health status on child maltreatment, and, therefore, this needs more attention.

Conclusions

Using a community sample of Chinese children, the study found that, even within children with normal intelligence and behavior, relatively more externalizing behaviors as rated by teachers and mothers are risk factors for children experiencing physical abuse from both mothers and fathers. In contrast, child internalizing behaviors as rated by mothers and teachers may decrease the risk of maternal minor physical abuse, which may be due to Chinese beliefs surrounding introversion (for a detailed discussion on Chinese belief of introversion and mental health, see [48]). IQ is not associated with any forms of physical abuse. The study findings may suggest that it is important to educate teachers and parents to assess and interpret children’s behavior appropriately and to communicate with children about their perceptions of their behavior to prevent parent–child conflicts and, in turn, to prevent child maltreatment.
References


Figure 4.1. The flow chart of the temporal design of the sub-cohort in the China Jintan Child Cohort Study and the present study. The gray area illustrates when the participants’ IQ, behaviors, and child maltreatment experiences were assessed in the present study. The number in each rectangle indicates the sample size with complete data on the variables of interest.
Table 4.1. Sample characteristics and their associations with child physical abuse (n=265)

<table>
<thead>
<tr>
<th></th>
<th>Total sample</th>
<th>Maternal Minor Physical Abuse</th>
<th>Paternal Minor Physical Abuse</th>
<th>Maternal Severe Physical Abuse</th>
<th>Paternal Severe Physical Abuse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M±SD /n (%)</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>140 (52.8)</td>
<td>67 (47.8)</td>
<td>73 (52.1)</td>
<td>55 (40.0)</td>
<td>83 (60.0)</td>
</tr>
<tr>
<td>Boys</td>
<td>125 (47.2)</td>
<td>64 (51.2)</td>
<td>61 (48.8)</td>
<td>58 (46.8)</td>
<td>66 (53.2)</td>
</tr>
<tr>
<td>Grade</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7th Grade</td>
<td>130 (49.1)</td>
<td>68 (50.7)</td>
<td>62 (47.3)</td>
<td>81 (54.4)</td>
<td>46 (40.7)</td>
</tr>
<tr>
<td>8th Grade</td>
<td>135 (50.9)</td>
<td>66 (49.3)</td>
<td>69 (52.7)</td>
<td>68 (45.6)</td>
<td>67 (59.3)</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>121 (45.7)</td>
<td>60 (49.6)</td>
<td>61 (50.4)</td>
<td>50 (42.0)</td>
<td>69 (58.0)</td>
</tr>
<tr>
<td>Suburban</td>
<td>116 (43.7)</td>
<td>57 (49.1)</td>
<td>59 (50.9)</td>
<td>51 (44.3)</td>
<td>64 (55.7)</td>
</tr>
<tr>
<td>Rural</td>
<td>28 (10.6)</td>
<td>14 (50.0)</td>
<td>14 (50.0)</td>
<td>11 (42.9)</td>
<td>16 (57.1)</td>
</tr>
<tr>
<td>Age</td>
<td>13.71±0.60</td>
<td>13.73±0.61</td>
<td>13.70±0.59</td>
<td>13.77±0.61</td>
<td>13.68±0.59</td>
</tr>
<tr>
<td>SES</td>
<td>0.06±1.18</td>
<td>0.03±1.19</td>
<td>0.10±1.18</td>
<td>0.10±1.20</td>
<td>0.04±1.18</td>
</tr>
</tbody>
</table>

Notes. The values displayed in the cells indicate mean ± standard deviations for continuous variables and frequency (percentage) for categorical variables. Family location was self-identified. SES, socioeconomic status. †, p<0.05.
Table 4.2. Abused children’s IQ and behavior problems (n=265)

<table>
<thead>
<tr>
<th></th>
<th>PIQ</th>
<th>VIQ</th>
<th>S_EXTER</th>
<th>M_EXTER</th>
<th>T_EXTER</th>
<th>S_INTER</th>
<th>M_INTER</th>
<th>T_INTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal Minor Physical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abuse Yes</td>
<td>105.30±11.64</td>
<td>100.77±11.48</td>
<td>50.92±10.25</td>
<td>51.31±9.36</td>
<td>50.23±8.74</td>
<td>49.99±10.60</td>
<td>51.20±10.89</td>
<td>50.54±10.44</td>
</tr>
<tr>
<td>No</td>
<td>106.71±12.62</td>
<td>101.30±11.40</td>
<td>47.85±8.76</td>
<td>48.35±7.97</td>
<td>49.56±7.84</td>
<td>47.58±9.31</td>
<td>48.62±8.80</td>
<td>50.64±10.16</td>
</tr>
<tr>
<td>Cohen's d</td>
<td>0.12</td>
<td>0.05</td>
<td>0.32*</td>
<td>0.34*</td>
<td>0.08</td>
<td>0.24†</td>
<td>0.26†</td>
<td>0.01</td>
</tr>
<tr>
<td>Paternal Minor Physical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abuse Yes</td>
<td>105.327±11.83</td>
<td>100.29±11.44</td>
<td>49.31±10.09</td>
<td>51.69±9.52</td>
<td>49.61±8.54</td>
<td>48.73±9.94</td>
<td>51.65±9.00</td>
<td>49.77±9.62</td>
</tr>
<tr>
<td>No</td>
<td>106.23±12.11</td>
<td>101.36±11.33</td>
<td>49.49±9.37</td>
<td>48.50±8.00</td>
<td>50.19±8.16</td>
<td>48.92±10.17</td>
<td>48.72±10.93</td>
<td>51.30±10.80</td>
</tr>
<tr>
<td>Cohen's d</td>
<td>0.08</td>
<td>0.09</td>
<td>0.02</td>
<td>0.37*</td>
<td>0.07</td>
<td>0.02</td>
<td>0.30†</td>
<td>0.15</td>
</tr>
<tr>
<td>Maternal Severe Physical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abuse Yes</td>
<td>103.24±12.52</td>
<td>99.74±11.60</td>
<td>50.96±9.82</td>
<td>51.35±8.75</td>
<td>51.85±10.20</td>
<td>50.96±11.59</td>
<td>50.59±9.70</td>
<td>52.50±9.25</td>
</tr>
<tr>
<td>No</td>
<td>106.93±11.91</td>
<td>101.47±11.37</td>
<td>48.84±9.53</td>
<td>49.31±8.77</td>
<td>49.25±7.50</td>
<td>48.05±9.36</td>
<td>49.66±10.05</td>
<td>49.96±12.78</td>
</tr>
<tr>
<td>Cohen's d</td>
<td>0.31†</td>
<td>0.15</td>
<td>0.22</td>
<td>0.23</td>
<td>0.32†</td>
<td>0.29†</td>
<td>0.09</td>
<td>0.25</td>
</tr>
<tr>
<td>Paternal Severe Physical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abuse Yes</td>
<td>106.19±12.09</td>
<td>101.05±11.73</td>
<td>49.21±9.03</td>
<td>52.32±9.69</td>
<td>52.16±10.40</td>
<td>48.82±9.92</td>
<td>51.63±10.63</td>
<td>52.23±12.02</td>
</tr>
<tr>
<td>No</td>
<td>105.96±12.19</td>
<td>101.03±11.35</td>
<td>49.42±9.83</td>
<td>49.03±8.37</td>
<td>49.19±7.41</td>
<td>48.76±10.07</td>
<td>49.35±9.69</td>
<td>50.08±9.65</td>
</tr>
<tr>
<td>Cohen's d</td>
<td>0.02</td>
<td>0.001</td>
<td>0.02</td>
<td>0.38*</td>
<td>0.36†</td>
<td>0.007</td>
<td>0.23</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Notes. PIQ: performance intelligence quotient; VIQ: verbal intelligence quotient; S_EXTER, child self-report externalizing behavior; M_EXTER, mother-report externalizing behavior; T_EXTER, teacher-report externalizing behavior; S_INTER, child self-report internalizing behaviors; M_INTER, mother-report internalizing behaviors; T_INTER, teacher-report internalizing behaviors. †, p<0.05; *, p<0.0125
### Table 4.3. The adjusted associations of IQ and behavior problems with physical abuse (n=265)

<table>
<thead>
<tr>
<th></th>
<th>Maternal Minor Physical Abuse adjusted OR (95%CI)</th>
<th>Paternal Minor Physical Abuse adjusted OR (95%CI)</th>
<th>Maternal Severe Physical Abuse adjusted OR (95%CI)</th>
<th>Paternal Severe Physical Abuse adjusted OR (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIQ</td>
<td>1.07(1.02, 1.13)†</td>
<td>0.93(0.76, 1.13)</td>
<td>1.07(0.61, 1.87)</td>
<td>1.14(0.99, 1.33)†</td>
</tr>
<tr>
<td>PIQ</td>
<td>0.87(0.59, 1.27)</td>
<td>0.88(0.70, 1.12)</td>
<td>0.78(0.37, 1.63)</td>
<td>1.03(0.80, 1.33)</td>
</tr>
<tr>
<td>S_EXTER</td>
<td>1.46(1.05, 2.03)†</td>
<td>1.15(0.93, 1.43)</td>
<td>0.88(0.54, 1.45)</td>
<td>0.59(0.52, 0.66)‡</td>
</tr>
<tr>
<td>M_EXTER</td>
<td>1.33(0.79, 2.25)</td>
<td>1.36(0.89, 2.07)</td>
<td>1.38(1.09, 1.74)†</td>
<td>1.47(1.29, 1.69)‡</td>
</tr>
<tr>
<td>T_EXTER</td>
<td>1.11(0.91, 1.35)</td>
<td>1.03(0.93, 1.15)</td>
<td>1.45(1.10, 1.91)†</td>
<td>1.61(1.44, 1.81)‡</td>
</tr>
<tr>
<td>S_INTER</td>
<td>1.02(0.85, 1.22)</td>
<td>0.85(0.60, 1.21)</td>
<td>1.41(0.96, 2.06)</td>
<td>1.20(0.57, 2.51)</td>
</tr>
<tr>
<td>M_INTER</td>
<td>1.02(0.68, 1.75)</td>
<td>1.13(0.78, 1.64)</td>
<td>0.77(0.63, 0.95)†</td>
<td>0.97(0.66, 1.41)</td>
</tr>
<tr>
<td>T_INTER</td>
<td>0.81(0.68, 0.97)†</td>
<td>0.86(0.64, 1.15)</td>
<td>0.88(0.79, 0.98)†</td>
<td>0.94(0.75, 1.16)</td>
</tr>
</tbody>
</table>

**Notes.** OR, odds ratio. OR values indicate a 10 point increase in IQ or behavior problems was associated with the change in the likelihood of being physically maltreated. IQ (range: 73-149) and behavioral (range: 35-92) independent variables are treated as continuous variables. 95% CI, 95% confidence interval. Models were adjusted for child gender, age, and socioeconomic status and clustered at location level to correct standard errors. PIQ: performance intelligence quotient; VIQ: verbal intelligence quotient; S_EXTER, child self-report externalizing behaviors; M_EXTER, mother-report externalizing behaviors; T_EXTER, teacher-report externalizing behaviors; S_INTER, child self-report internalizing behaviors; M_INTER, mother-report internalizing behaviors; T_INTER, teacher-report internalizing behaviors. †, p<0.05; *, p<0.0125; **, p<0.001
Supplemental Material

Power Analysis Procedure

Three parameters are needed for power calculation: alternative Odds Ratio (OR), baseline probability and the $R^2$ of key independent variable with other covariates. The alternative OR was identified from a study of 1,505 Chinese children (mean age 9.50±1.77). This study estimated that the odds ratio of child behavior problems in relation to minor and severe physical abuse were 1.90 and 2.40, respectively (Ma et al., 2011). The minimum value (i.e., 1.90) was selected. The estimated baseline probability of physical abuse was 0.22 in the children with self-report externalizing behaviors below the mean level (49.37) in the present study. The $R^2$ when self-report externalizing behaviors regress on the other covariates was 0.55 in this study. All parameters were submitted to the logistic regression module in PASS 15. The estimated power to reject a false null hypothesis is 0.90 in the study. Below is the power analysis report from PASS 15.

Reference:

Power Analysis Report

Logistic Regression

Numeric Results

<table>
<thead>
<tr>
<th>Power</th>
<th>N</th>
<th>P0</th>
<th>P1</th>
<th>Odds Ratio</th>
<th>R Squared</th>
<th>Alpha</th>
<th>Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.90863</td>
<td>265</td>
<td>0.330</td>
<td>0.483</td>
<td>1.900</td>
<td>0.550</td>
<td>0.05000</td>
<td>0.09137</td>
</tr>
</tbody>
</table>

References

Report Definitions
Power is the probability of rejecting a false null hypothesis. It should be close to one.
N is the size of the sample drawn from the population.
P0 is the response probability at the mean of X.
P1 is the response probability when X is increased to one standard deviation above the mean.
Odds Ratio is the odds ratio when P1 is on top. That is, it is $[P1/(1-P1)]/[P0/(1-P0)]$.
R-Squared is the R2 achieved when X is regressed on the other independent variables in the regression.
Alpha is the probability of rejecting a true null hypothesis.
Beta is the probability of accepting a false null hypothesis.
Summary Statements
A logistic regression of a binary response variable (Y) on a continuous, normally distributed variable (X) with a sample size of 265 observations achieves 91% power at a 0.05000 significance level to detect a change in Prob(Y=1) from the value of 0.330 at the mean of X to 0.483 when X is increased to one standard deviation above the mean. This change corresponds to an odds ratio of 1.900. An adjustment was made since a multiple regression of the independent variable of interest on the other independent variables in the logistic regression obtained an R-Squared of 0.550.

Dropout-Inflated Sample Size

<table>
<thead>
<tr>
<th>Dropout Rate</th>
<th>Sample Size N</th>
<th>Enrollment Sample Size N'</th>
<th>Expected Number of Dropouts D</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>265</td>
<td>332</td>
<td>67</td>
</tr>
</tbody>
</table>

Definitions
Dropout Rate (DR) is the percentage of subjects (or items) that are expected to be lost at random during the course of the study and for whom no response data will be collected (i.e. will be treated as "missing").
N is the evaluable sample size at which power is computed (as entered by the user). If N subjects are evaluated out of the N' subjects that are enrolled in the study, the design will achieve the stated power.
N' is the total number of subjects that should be enrolled in the study in order to end up with N evaluable subjects, based on the assumed dropout rate. N' is calculated by inflating N using the formula N' = N / (1 - DR), with N' always rounded up. (See Julious, S.A. (2010) pages 52-53, or Chow, S.C., Shao, J., and Wang, H. (2008) pages 39-40.)
D is the expected number of dropouts. D = N' - N.

Logistic Regression

Procedure Input Settings

Autosaved Template File
C:\Users\naixuec\Documents\PASS 15\Procedure Templates\Autosave\Logistic Regression - Autosaved 2017_4_17-8_49_52.t123

Design Tab
Solve For: Power
Alternative Hypothesis: Two-Sided
Alpha: 0.05
N (Sample Size): 265
P0 (Baseline Probability that Y=1): 0.33
Use P1 or Odds Ratio: Odds Ratio
Odds Ratio (Odds1/Odds0): 1.9
R-Squared of X1 with Other X's: 0.55
X1 (Independent Variable of Interest): Continuous (Normal)
Supplemental Table S4.1. Comparisons of sample characteristics between children that were included (n=265) and excluded (n=775) in the study

<table>
<thead>
<tr>
<th>Sociodemographic Characteristics</th>
<th>Included</th>
<th>Excluded</th>
<th>$t$/$\chi^2$</th>
<th>$p$</th>
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</thead>
<tbody>
<tr>
<td><strong>Gender ($n_e=775$)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>140 (52.8)</td>
<td>333 (43.0)</td>
<td>7.75</td>
<td>0.005</td>
</tr>
<tr>
<td>Boys</td>
<td>125 (47.2)</td>
<td>442 (57.0)</td>
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<tr>
<td><strong>Grade ($n_e=775$)</strong></td>
<td></td>
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<tr>
<td>6th grade</td>
<td>117 (44.2)</td>
<td>304 (39.23)</td>
<td>1.99</td>
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<td>7th grade</td>
<td>148 (55.8)</td>
<td>471 (60.77)</td>
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<tr>
<td><strong>Location ($n_e=775$)</strong></td>
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<tr>
<td>Urban</td>
<td>121 (45.7)</td>
<td>278 (35.9)</td>
<td>34.60</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Suburban</td>
<td>116 (43.7)</td>
<td>277 (35.7)</td>
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</tr>
<tr>
<td>Rural</td>
<td>28 (10.6)</td>
<td>220 (28.4)</td>
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<tr>
<td><strong>Age ($n_e=775$)</strong></td>
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<tr>
<td><strong>Child Physical Abuse</strong></td>
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<tr>
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<td>134 (50.6)</td>
<td>208 (51.4)</td>
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<tr>
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<td>197 (48.6)</td>
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<td>No</td>
<td>149 (56.9)</td>
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<td>180 (44.4)</td>
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<tr>
<td>Maternal severe physical abuse ($n_e=405$)</td>
<td>No</td>
<td>199 (75.1)</td>
<td>318 (78.5)</td>
<td>1.24</td>
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<td>Yes</td>
<td>66 (24.9)</td>
<td>87 (21.5)</td>
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<td>202 (76.2)</td>
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<td><strong>Intelligence</strong></td>
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<tr>
<td>VIQ ($n_e=222$)</td>
<td>101.04±11.42</td>
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<td>106.01±12.14</td>
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<td>0.223</td>
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<tr>
<td><strong>Child Behavior</strong></td>
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<td>S_EXTER ($n_e=269$)</td>
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<td>48.90±9.82</td>
<td>0.56</td>
<td>0.57</td>
</tr>
<tr>
<td>M_EXTER ($n_e=211$)</td>
<td>49.82±8.79</td>
<td>49.61±9.93</td>
<td>0.24</td>
<td>0.809</td>
</tr>
<tr>
<td>T_EXTER ($n_e=246$)</td>
<td>49.89±8.29</td>
<td>50.77±49.45</td>
<td>1.05</td>
<td>0.292</td>
</tr>
<tr>
<td>S_INTER ($n_e=269$)</td>
<td>48.77±10.02</td>
<td>49.55±9.29</td>
<td>0.93</td>
<td>0.353</td>
</tr>
<tr>
<td>M_INTER ($n_e=211$)</td>
<td>49.89±9.95</td>
<td>50.16±9.64</td>
<td>0.29</td>
<td>0.768</td>
</tr>
<tr>
<td>T_INTER ($n_e=246$)</td>
<td>50.59±10.28</td>
<td>50.65±9.91</td>
<td>0.07</td>
<td>0.94</td>
</tr>
</tbody>
</table>

**Notes.** $a$, $n_e$ represents the sample size of excluded children with relevant data. The values displayed in the cells indicate mean ± standard deviations for continuous variables and frequency (percentage) for categorical variables. SES, socioeconomic status. PIQ: performance intelligence quotient; VIQ: verbal intelligence quotient; S_EXTER, child self-report externalizing behaviors; M_EXTER, mother-report externalizing behaviors; T_EXTER, teacher-report externalizing behaviors; S_INTER, child self-report internalizing behaviors; M_INTER, mother-report internalizing behaviors; T_INTER, teacher-report internalizing behaviors. A large amount of children were not included because only a proportion of children’s IQ was assessed, and because of incomplete behavior data from all three informants, dropout and loss to follow-up.
CHAPTER 5: CONCLUSION

Overview of Background and Specific Aims

CM, especially PA, is especially prevalent in Mainland China. CM is associated with childhood BP, which further predicts adult crime, violence and mental disorders (Leschied et al., 2008; Reef et al., 2011). Childhood is also a critical window for neurocognitive development. Major gaps exist in understanding the interrelations among these three constructs in the literature, especially in Chinese literature. Specifically, the magnitude of the associations between CM and childhood BP in Mainland China have not been systematically examined using the meta-analytic approach. The neurocognitive mechanism underlying the relationship between PA and BP remains poorly understood. The knowledge on whether child’s neurocognitive and behavioral profiles increase the risk of PA in the Chinese context is limited.

This dissertation was designed to gain a better understanding of the complex interrelations among CM, BP, and neurocognition. The specific aims were (a) to estimate the mean effect size of the relationships between CM (i.e., PA, EA, and neglect) and childhood BP using meta-analysis, (b) to test the mediating effect of neurocognition measured by P300 ERP in the relationship between PA and externalizing behaviors, informed by the parent effect model, and (c) to examine the risk effects of neurocognitive dysfunction measured by IQ and BP in earlier life on later PA, guided by the child effect model.

Summary of Findings

Overall, findings of this dissertation add to the currently limited literature of the interrelations among CM, BP, and neurocognition. First, corresponding to Aim 1, the
meta-analysis revealed that in Mainland China, PA, EA, and neglect are undoubtedly related to a spectrum of childhood BP, despite the substantial heterogeneity among study findings. In addition, an exploratory comparison of the findings of this study with those of five existing meta-analyses (Ip et al., 2016; Lindert et al., 2014; Mandelli, Petrelli, & Serretti, 2015; Norman et al., 2012; Wilson, Norris, Shi, & Rack, 2010) showed that the associations between CM and BP are about equal across child and adult populations and across countries.

With this background and guided by the parent effect model, the second aim examined the neurocognitive mediation in the relationship between PA and externalizing behaviors, using secondary data from a subcohort of the China Jintan Child Cohort Study. Findings showed that children with maternal physical abuse experience showed increased P300 amplitude to novel auditory stimuli, indicating they allocate more attentional resources to unfamiliar and task-irrelevant cues. Increased novelty P300 amplitude further mediated the relationship between maternal physical abuse and self-report externalizing behaviors.

In addition, guided by the child effect model, the third aim was achieved through another quantitative secondary analysis of existing data from the China Jintan Child Cohort Study. The findings revealed that in children with relative normal intelligence and behavior, mother- or teacher-perceived child externalizing behaviors increased risks of experiencing parental physical abuse, whereas self-reported externalizing behaviors or mother-reported internalizing behaviors was associated with decreased risks of paternal or maternal physical abuse, respectively. Verbal IQ was associated with maternal physical abuse with a very small effect size, whereas performance IQ
did not associate with any forms of physical abuse. The findings suggest that discrepancies in child externalizing behaviors perceived by children, mothers, and teachers may be a source of parent–child conflict and increase the risk of parental use of harsh parenting.

**Implications for Future Research**

The present findings shed light on future research. The meta-analysis demonstrated that existing Chinese studies on CM and BP were conducted in child samples with relatively homogeneous characteristics. In other words, the children were recruited from regular school settings in the regions where Han Chinese is the majority. Researchers should also study children who attend special-education schools or who do not attend schools, and children in the 55 minority ethnic groups in Mainland China.

More studies are also needed to investigate the relationship between multiple types of CM and childhood BP. Researchers found that different forms of CM usually occur simultaneously (Wang & Liu, 2014). Co-occurring CM has cumulative effects on child behavior that are stronger than the effects of individual types of CM (Appleyard, Egeland, Dulmen, & Sroufe, 2005).

Future studies with more sophisticated longitudinal designs will provide further investigation of the transactional interrelations among CM, BP, and neurocognition. Emerging evidence supports a bidirectional relationship between CM and BP (e.g., Combs-Ronto, Olson, Lunkenheimer, & Sameroff, 2009; Lansford et al., 2011; Pardini, Fite, & Burke, 2008; Sheehan & Watson, 2008). This dissertation provided preliminary evidence that CM, BP, and neurocognition interrelate under the parent effect and the child effect models separately. Longitudinally designed studies with repeated measures of
each construct over time will help further reveal the dynamic influences among these constructs in childhood by integrating the parent effect and child effect together.

The meta-analysis found that the strength of the relationship between CM and BP may differ by gender in China. Yet, the evidence is weak due to the small number of studies that stratified their analyses by child gender. Child gender could be an important moderator in the relationships among CM, BP, and neurocognition and should be further explored.

In addition, future research is critical in the area of population-based interventions that address CM. Intervention studies aimed to prevent and manage CM have shown effectiveness in reducing CM in many countries (for reviews, see Chen & Chan, 2016; Mikton & Butchart, 2009). However, to the best of my knowledge, no evidence-based prevention and intervention programs were developed and tested with children in Mainland China. Therefore, researchers need to tailor prevention programs and interventions to the Chinese sociocultural context and investigate their effectiveness in Chinese children.

**Implications for Future Practice**

This dissertation has implications for practice. Findings that CM undoubtedly relates to a broad spectrum of childhood behavior problems in Mainland China shows the importance of prevention of CM. Programs that transform the traditional belief of using PA, EA, and neglect as normative disciplinary tools are critical to reducing parental use of CM. This goal may be achieved by programs to raise public awareness of the detrimental association between CM and child behavioral development. Education programs on positive parenting (e.g., Chen & Chan, 2016) to teach parents effective
parenting skills and correct misperceptions of child behaviors, improve parents’ problem-solving ability, and increase positive parent–child interactions among Chinese parents are in need.

Findings suggested that neurocognition may be targeted to prevent or treat BP among physically abused children. Physically abused children may be dysfunctional in processing novel or surprising cues in the environment, which in turn places them at high risk of externalizing behaviors. Research shows that environmental enrichment (e.g., Petrosini et al., 2009; Raine, Mellingen, Liu, Venables, & Mednick, 2003), physical activity (e.g., Sibley & Etnier, 2003) and better nutrition (Georgieff, 2007) are helpful to improve neurocognition and brain functioning. These intervention strategies may be applied to abused child survivors to maintain normal neurocognitive and behavioral development or improve impaired neurocognition.

In addition, given that Mainland China still lacks an effective child-protection system (Man et al., 2017; Peng et al., 2015), findings signify the urgency and importance of building an effective and implementable system to protect children from CM. In addition, services for at-risk families (e.g., families with parents or children with relatively disadvantaged neurocognitive and behavioral profiles), which are currently not available in Mainland China, should be designed and implemented.
References


APPENDICES

Appendix A. Coding Form for the Meta-analysis

[Variable Names in Brackets]

Publication Characteristics

1. Study ID [studyid]:______________
2. Study name [study]: ______________(last name(s) of first author (or two authors if there is only co-author), year)
3. Type of article [pubtype]
   1 book or book chapter 2 peer-reviewed journal article 3 thesis or doctoral dissertation 4 conference paper 5 other
   3a. if other, specify [pubtype2]________________

Sample Characteristics

4. Sample size (number) [samplesize]:______________
   4a. Large or small sample size (samplesize_di)
      1 Large \( n \geq 1,000 \) 0 Small \( n < 1,000 \)
5. Response rate [rr]:______________
   5a. If response rate was not reported, usable return rate [urr]:______________ or 99 not specified
6. Gender (percentage of female participants) [gender]:________________
7. Mean age [meanage]:___________ and Standard deviation of age sdage]:______________ or age range [agerange]______________ or grade [grade]____________
8. Probability sampling [sampling]
   1 Yes 0 No
9. Location (e.g. province or city in China) [region]
   1 Northeast 2 South central 3 Northwest 4 Southwest 5 East 6 North 7 South
   88 Multiple regions 99 not specified

Child Maltreatment and Behavior Problems

10. Provide specific definition of child maltreatment [maltreat_def]
    1 Yes 0 No
11. Child maltreatment type
    11.1 Physical Abuse [pa] 1 Yes 0 No
    11.2 Emotional Abuse [ea] 1 Yes 0 No
    11.3 Neglect [neg] 1 Yes 0 No
    11.4 Mixed Abuse [ma] 1 Yes 0 No
12. Abusers [abuser]:

1 Mother  2 Father  3 Both mother and father  4 Other family members  5 Mixed: parents, guardians, or other family members in the household

13. Behavior problems

13.1  **Level 1 behavior problems**
13.1.1 Externalizing behaviors [bhv_ext]  1 Yes  0 No
13.1.2 Internalizing behaviors [bhv_int]  1 Yes  0 No
13.1.3 Mixed behavior [bhv_mixed]  1 Yes  0 No

13.2  **Level 2 behavior problems**
13.2.1 Aggression [bhv_agg]  1 Yes  0 No
13.2.2 Delinquency/antisocial behavior [bhv_del]  1 Yes  0 No
13.2.3 Hyperactivity [bhv_hyp]  1 Yes  0 No
13.2.4 Anxiety [bhv_anx]  1 Yes  0 No
13.2.5 Depression [bhv_dep]  1 Yes  0 No
13.2.6 Somatic complaints [bhv_som]  1 Yes  0 No
13.2.7 Suicidal attempts [bhy_sa]  1 Yes  0 No
13.2.8 Suicidal ideation [bhy_si]  1 Yes  0 No
13.2.9 Self-harm [bhv_sf]  1 Yes  0 No
13.2.10 Other [bhv_other1]  1 Yes  0 No
13.2.10a if other, specify [bhv_other2] _________________

**Methodological Factors**

14. Study design [design]  
0 cross-sectional  1 longitudinal/cohort study  2 case-control  99 not specified

15. Single or multiple sites [site_num]  
1 single site  0 multiple sites  99 not specified

16. Urban or rural studies [site_loc]  
0 rural study  1 urban study  2 mixed  99 not specified

17. Validated instrument of child maltreatment [valid_cmtool]  
1 validated instrument  0 invalidated instrument

18. Type of instrument [type_cmtool]  
1 CTS  2 CTQ  0 others  99 not specified

19. Reporter of child maltreatment [reporter_cm]  
0 child  1 parent  2 official records  99 not specified

20. Measurement of child behavior [bp_tool]  
0 Questionnaire  1 Diagnosed  2 Others

21. Study quality [quality]  
0 low  1 medium  2 high

**Some Guidance for Coding Data for the Meta-Analysis**

5. **Response rates** were calculated by dividing the number of usable responses returned by the total number eligible in the sample chosen.
5a. **Usable return rates** were calculated by dividing number of usable responses returned by the total number of questionnaires distributed.

11. **Child maltreatment type:** see definitions in Table 2.1

13: **Behavior type:** see definitions in Table 2.1

16. **Urban or rural studies:** this is defined by if the participants were from urban or rural areas. In China, rural residents are officially different from urban residents because rural residents hold farmers resident card.

17, 18, 19: If there are multiple types of child maltreatment and/or multiple types of behavior problems, items 17, 18, and 19 can be repeated and variable names should be changed accordingly to correspond with each type of child maltreatment and/or behavior problems.

21. **Study quality:** Assess the quality of each study using the modified Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies (Appendix B). Each item in the scale is worth one point and higher points indicate better study quality. Study quality was regarded as high if the summed points were higher than half of the total number of items that applied to the study, otherwise as low.
## Appendix B. Adapted Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies (National Institute of Health, 2014)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Yes (1)</th>
<th>No (0)</th>
<th>Other (CD, NR, NA)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Was the research question or objective in this paper clearly stated?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Was the study population clearly specified and defined?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Was the participation rate of eligible persons at least 50%?</td>
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</tr>
<tr>
<td>4a. Were all the subjects selected or recruited from the same or similar populations (including the same time period)?</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4b. Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>5. Was a sample size justification, power description, or variance and effect estimates provided?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Were the exposure measures (independent variables) valid and reliable in Chinese children?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Was the exposure(s) assessed more than once over time?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Were the outcome measures (dependent variables) valid and reliable in Chinese children?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Were the outcome assessors blinded to the exposure status of participants?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Was loss to follow-up after baseline 20% or less?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Quality Rating (Good, Fair, or Poor) (see guidance)

Rater #1 initials:  
Rater #2 initials:  

Additional Comments (If POOR, please state why):

*Notes: CD, cannot determine; NA, not applicable; NR, not reported. Detailed guidance for using the assessment tool is available in NIH (2014). Items 7, 10 and 13 are not applied to cross-sectional studies.